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RUSSIAN RIVER RED SALMON STUDY

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ALASKA DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner
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STUDY AFS-44-2

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

RUSSIAN RIVER
RED SALMON STUDY

by

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ALASKA DEPARTMENT OF FISH AND GAME
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RESEARCH PROJECT SEGMENT

State: ALASKA

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Job No.: AFS 44-2 Job Title: Russian River Red Salmon Study

Period Covered: July 1, 1975 to June 30, 1976.

ABSTRACT

A creel census was conducted during the Russian River red salmon, *Oncorhynchus nerka* (Walbaum), sport fishery to determine harvest and effort. Census revealed 16,510 man-days of effort were expended to harvest 9,790 salmon. Early and late runs contributed 1,400 and 8,390 fish, respectively, to this harvest. Early run catch is the lowest recorded since the inception of the creel census in 1963. Seasonal success rate (both runs combined) was 0.140 red salmon per hour. Anglers harvested 20.7% of the red salmon that reached Russian River.

Early and late run escapements of red salmon were enumerated by weir at the outlet of Lower Russian Lake. Early run escapement of 5,640 salmon is one of the lowest recorded. It is estimated late run Russian River escapement (31,970) comprised 25.3% of the Kenai River escapement.

Scale analysis of early and late run red salmon revealed both runs were dominated by fish which resided two years in freshwater. Early run salmon were primarily three-ocean (78.2%) while the late run was dominated by two-ocean fish. Lengths of early and late run adult red salmon averaged 588.3 and 531.3 mm, respectively. Length-frequency data for both runs are presented and the feasibility of determining ocean age by size discussed.

Fecundity investigations conducted at Lower Russian Lake weir revealed early and late run red salmon average 3,952 and 3,554 eggs per female, respectively. For the second consecutive year, a comparison of actual egg count to volumetric estimate indicated minimal error and justifies greater use of volumetric determination in future investigations. Early and late run salmon utilized in these studies averaged 2,540 and 2,257 kg in total weight, respectively. In the majority of the fish examined (87.9%) the left skein contained a greater number of eggs than did the right skein.

Hydraulic egg sampling in Upper Russian Creek revealed early run egg deposition to be 33.3 eggs/M^2. This is the lowest density since sampling began in 1972. Egg survival was 84.3% at time of sampling. Eggs were in the "eyed" stage when sampling was conducted on October 16-18, 1975. Egg sampling in Bear Creek revealed late run egg deposition to be 503 eggs/M^2. This is also the lowest density recorded since 1972.

A weir at the outlet of Bear Creek, a small spring-fed tributary to Upper Russian Lake revealed 1,138 late run red salmon spawned in this area. Tagging investigations, coupled with data from prior years suggest stream life (days fish spent in the stream) in this system approximates 15.0 to 24.2 days. Daily ground surveys of the stream indicated brown bear, Ursus arctos, activity was exceptionally intense. An estimated 973 salmon (85.5% of the Bear Creek escapement) were harvested by this predator. Egg sampling suggests the majority of these fish had successfully spawned prior to capture. Data are also presented regarding accuracy of ground surveys and areas within Bear Creek utilized by spawning fish.

Sampling to detect the presence of IHN (infectious hematopoietic necrosis) revealed 100% of early and late run females examined were infected. Early and late run male salmon were 45.5% and 20.0% positive, respectively, for the disease. The effect(s) of this virus on Upper Russian Lake red salmon reproductive potential is not presently known.

Climatological data were collected at Lower and Upper Russian lakes. No correlation was established between water temperature and migration of red salmon through Russian River or into Bear Creek. Observation suggested early run salmon may have been delayed at Russian River Falls by a velocity barrier. Delay was minimal and is assumed to have had no adverse effect on reproductive potential of early run salmon.

BACKGROUND

The Russian River red salmon sport fishery is located adjacent to the Sterling Highway at Mile 55, approximately seven miles west of the Kenai Peninsula community of Cooper Landing. In this area the clear Russian River enters the larger glacial Kenai River system. At this point a privately operated ferry transports anglers to the south bank. Approximately 50% of all angler effort on red salmon occurs in this area.

Red salmon sport fishing is presently restricted to lower Russian River from a marker 600 yards below Russian River Falls to a marker 1,800 yards below the Kenai and Russian River confluence, a distance of approximately three river miles. Only coho or streamer flies, with a gap between point and shank no greater than 3/8", are permitted as legal sport fishing gear in this area from June 1 through August 31. The area between a marker below the ferry crossing dock and a marker 700 yards upstream on Russian River is closed to all sport fishing from June 1 through July 14 (Figure 1).

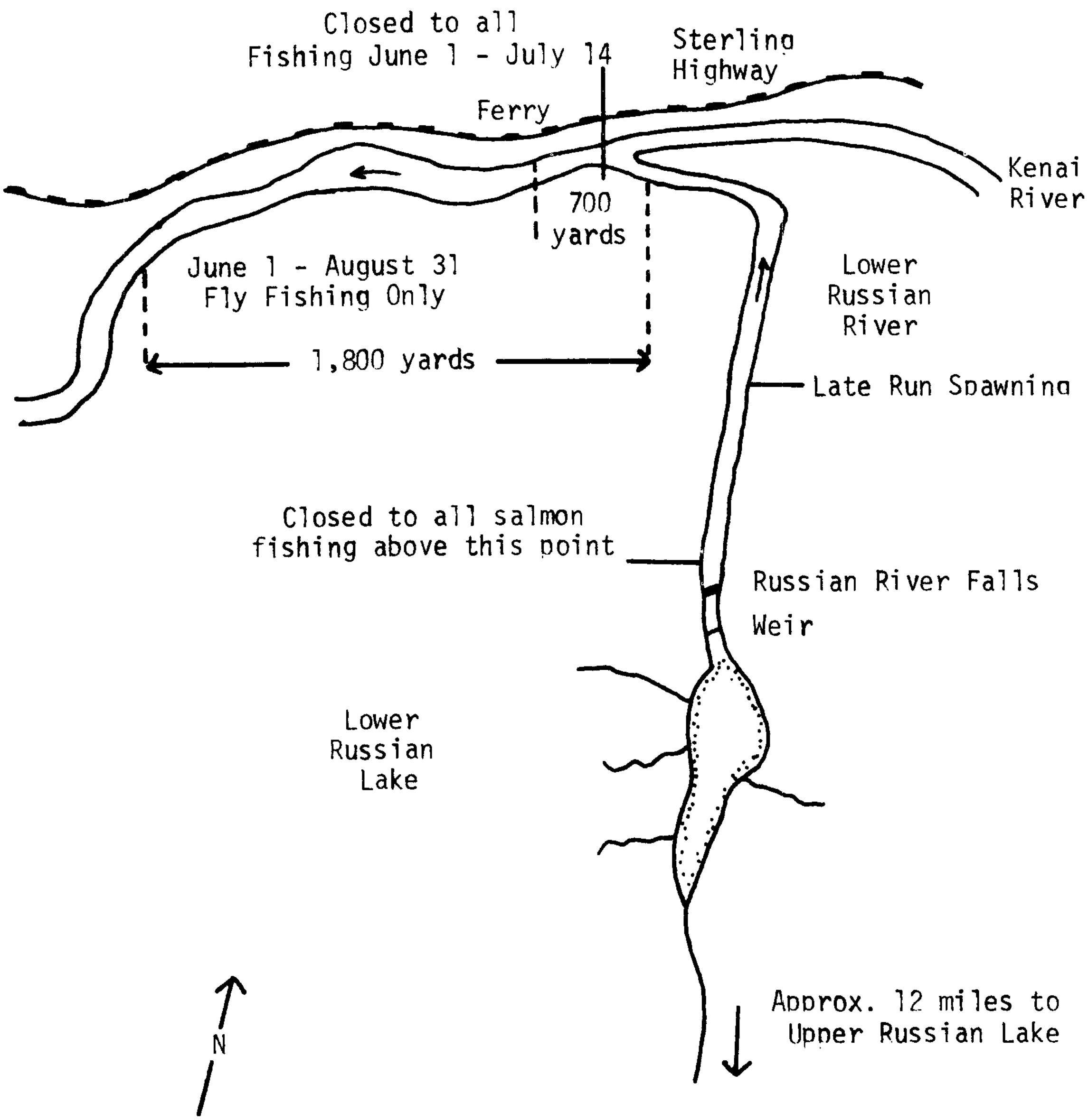

Figure 1. Schematic Diagram of Lower Russian River and Kenai and Russian River Confluence (Not To Scale).

Russian River red salmon runs are bimodal in nature, i.e., there are two distinct runs. Early run salmon generally enter the sport fishery between June 10-15, and by July 4 approximately 50% of the early run have passed through the weir at Lower Russian Lake. This is the smaller of the two runs, averaging 17,143 fish (13-year mean) annually. The late run enters the fishery in mid-July and averages 46,448 red salmon annually (13-year mean). Approximately 50% of this run have passed through the weir by August 3. Red salmon migration in Russian River generally terminates by September 1.

Russian River also supports chinook, *Oncorhynchus tshawytscha* (Walbaum), silver, *O. kisutch* (Walbaum), and a few pink, *O. gorbuscha* (Walbaum), salmon. Resident game species include rainbow trout, *Salmo gairdneri* Richardson, and Dolly Varden, *Salvelinus malma* (Walbaum).

Lower Russian River from its confluence with Kenai River to a point approximately two miles upstream is of moderate gradient. This area is the spawning ground for a small segment (averaging 7.6% annually) of the late run.

Upstream from this point the stream travels through a canyon of considerable gradient commonly called Russian River Falls. During the past 15 years, salmon have been delayed in the canyon on several occasions due to abnormally high water. The most serious recorded delay occurred in 1971 when an estimated 10,000-12,000 late run fish perished below the obstruction (Engel, 1972). Mortalities caused by delays of early and late run salmon during prior years have not been documented.

Lower Russian Lake supports an active sport fishery for Dolly Varden and rainbow trout. It is a shallow lake with a maximum depth of 25 feet and a surface area of 215 acres. The lake contains no known salmon spawning areas.

Upper Russian River enters Lower Russian Lake from the south. This stream contains excellent spawning gravel and connects Upper and Lower Russian lakes. Late run red salmon spawn above a rapids located three miles below Upper Russian Lake. Observation indicates silver and chinook salmon utilize the entire stream.

Upper Russian Lake (Figure 2) is a clear, deep lake approximately 3.0 miles long and 0.75 miles wide. Surface area is 1,100 acres and maximum depth exceeds 240 feet. Majority of late run red salmon spawn in various areas of the lake. In addition to suspected spring areas, the lake is fed by five tributaries, the largest of which are Upper Russian and Bear creeks.

Upper Russian Creek is the lake's major tributary entering from the south. The stream is clear except during warm periods when it may assume glacial coloration. Excellent spawning gravel is found in the first 1.1 miles. Beyond this point a canyon of considerable gradient is a total barrier to adult salmon migration. This is the only spawning area utilized by the early run. A small segment of the late run also spawns here.

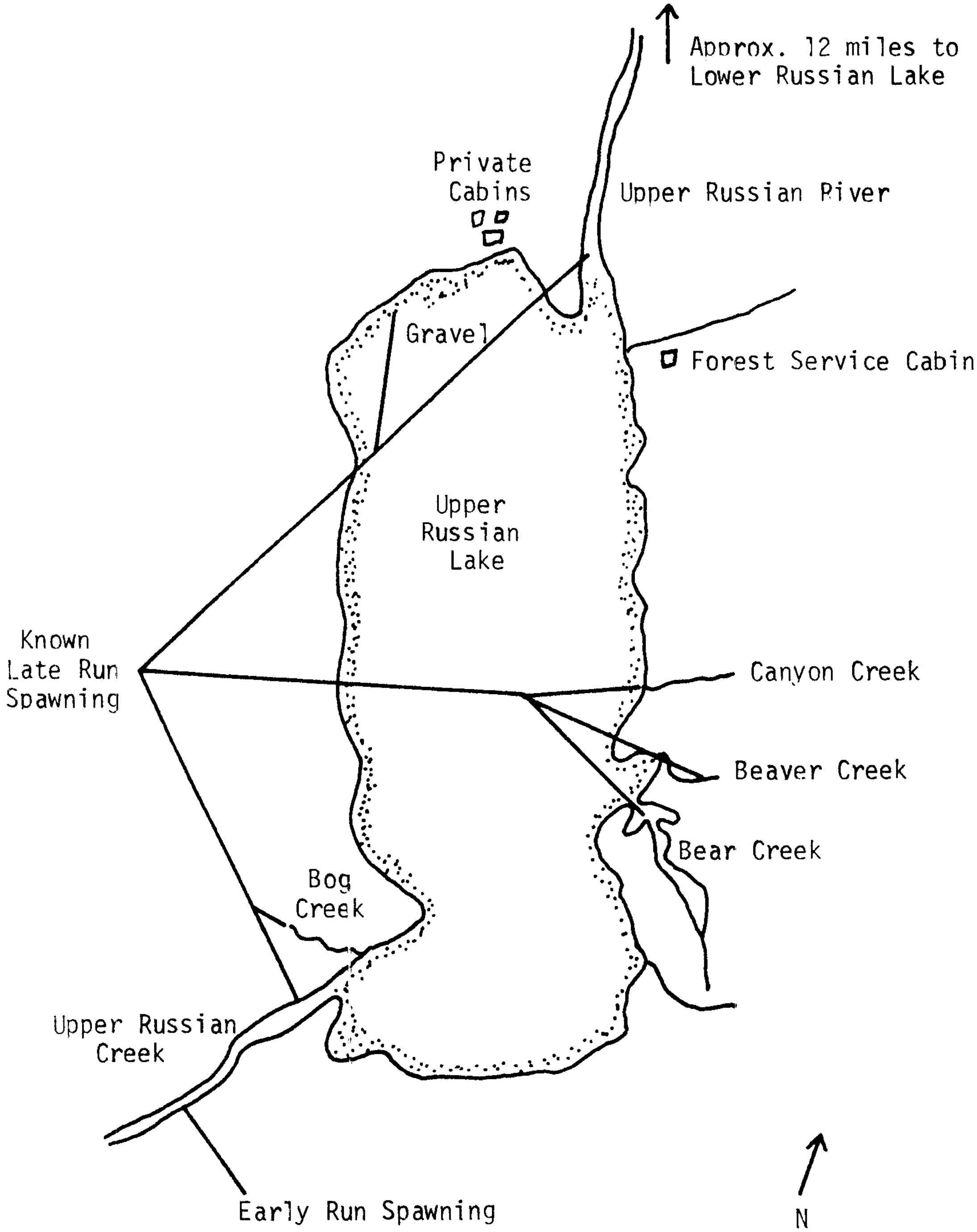

Figure 2. Schematic Diagram of Upper Russian Lake (Not To Scale).

Bear Creek is a relatively small spring fed tributary on the east side of Upper Russian Lake. It is characterized by stream areas connecting four spring fed ponds. Observations by Nelson (1973, 1974, 1975) indicate pond areas are the preferred spawning areas of late run red salmon, the only salmon known to spawn here. Average depth is approximately one foot and extensive salmon mortality associated with brown bear predation is known to occur.

Management and research activities associated with this complex system have been carried out by the Sport Fish Division of the Alaska Department of Fish and Game since 1962. Prior information relating to this fishery has been presented in Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Progress Reports by Lawler (1963, 1964), Engel (1965 through 1972), and Nelson (1973, 1974). In 1974 Russian River investigations were partially financed with Anadromous Fish Act funds. Results of these studies have been presented by Nelson, (1975).

Since the inception of the research investigations, it has been recognized that Russian River provides one of Alaska's most important freshwater fisheries (Lawler, 1963). Fishing effort has continued to intensify concomitant with increased leisure time and an expanding Alaskan population. Depending on run size, anglers may expend up to 30,590 man-days of effort annually.

To monitor angler effort and derive accurate harvest estimates, a creel census has been conducted annually. During the 14 years the census has been active, Fish and Game personnel have contacted more than 57,000 anglers who reported harvesting in excess of 40,000 red salmon. Fishermen have annually averaged 0.8 red salmon per angler day since 1963. Total harvest over a 13 year period is estimated at 159,590 salmon.

Prior to 1967 salmon harvested per angler day averaged 1.1. Between 1967 and 1975 this average decreased to 0.7. This decrease should not be interpreted as a decline in angling quality or red salmon abundance, but rather as due to regulatory measures designed to eliminate snagging.

Snagging, which involves retrieving a hook through the water in such a manner that the fish is impaled without hooking it in the mouth (Engel, 1965), has been a popular method of harvesting red salmon since the inception of this fishery. Many anglers opposed this method on ethical grounds, but the technique persisted because of the traditional belief that this species will not readily take bait or strike a lure.

Criticism of this angling method intensified with growth of the fishery and in 1965 the Alaska Board of Fish and Game prohibited the use of treble hooks in an attempt to limit the practice. In 1967 further restrictions were imposed which limited terminal gear and required any fish not hooked in head, mouth, or gills be immediately released.

Public acceptance of these "anti-snagging" regulations was not universal. An angler poll conducted by Engel (1968) indicated only 50.6% of Russian River anglers favored these restrictions. Delayed mortality, purported to occur when a salmon was foul-hooked (snagged) and subsequently released, was a primary concern of those who opposed the regulation (Engel, 1971).

To determine the degree of delayed mortality which may occur when a salmon was foul-hooked and released Engel (1970, 1971, 1972) conducted tagging experiments within the fishery and at Lower Russian Lake weir. Data collected during these investigations indicate most red salmon survive after being foul-hooked and successfully negotiate Russian River Falls. It was further concluded that unmarked and superficially wounded fish experience a higher degree of spawning success than moderate or severely wounded salmon.

Nelson (1973) continued the tagging experiments initiated by Engel in 1969. Data collected in 1972 indicated minimum mortality below Russian River Falls. Tag recoveries on spawning grounds at Upper Russian Lake supported Engel's findings. It was concluded that although limited mortality does occur when a salmon is foul-hooked and released, it does not pose a biological problem in the management of the Russian River sport fishery (Nelson, 1973a).

In 1973 the Board of Fish and Game promulgated a regulation requiring any fish not hooked in the mouth be immediately released. Public acceptance of this regulation was excellent, as 78.8% of the anglers polled at Russian River favored its adoption (Nelson, 1974). In 1975 the Board approved a proposal prohibiting the intentional snagging of sport fish in fresh water. Although no formal poll was conducted, angler compliance was again excellent, and it is believed this regulation effectively ended the controversial snagging issue at Russian River. A summary of regulations governing this fishery from 1960-1966 has been presented by Engel (1967). Regulatory changes since 1966 are presented in Table 1.

Table 1 indicates the Russian River red salmon sport fishery is becoming increasingly restrictive. These restrictions were necessitated due to increased angling pressure. Participation from 1963-1968 averaged 12,575 man-days. From 1969-1975 average effort increased 53.0% to 19,238 man-days. Effort became so intense that, despite anti-snagging regulations, the sport fishery was capable of harvesting the bulk of the salmon to reach Russian River. A fishery of this magnitude requires an intensive management program to insure adequate protection of the stocks.

To afford increased protection to early run salmon, a closed or sanctuary area was established at the confluence of Kenai and Russian rivers in 1972. This is an historic resting area for early run fish which may require up to 14 days to pass through the fishery and are subject to repeated capture. The area was closed to all fishing June 1-June 30. Late run fish pass through the fishery in approximately six days and do not require this additional protection. (Nelson, 1973).

In 1973 the fly-only area was extended from 500 to 1,800 yards below the confluence of the Kenai and Russian Rivers. In 1974 the closure at the confluence was extended from June 1-July 14 and in 1975 this area was increased an additional 200 yards upstream (Table 1).

Table 1. Annual Regulations Governing the Russian River Red Salmon Sport Fishery, 1967-1975.

Year	Snagging	Fly-Only Area**
1967*	A fish hooked elsewhere than head, mouth, or gills must be immediately released.	Fly-only area from 600 yards below Russian River Falls to a marker 500 yards below Kenai/Russian River confluence June 1-August 31.
1968	Same as 1967	Same as 1967
1969	Same as 1967	Same as 1967
1970	Same as 1967	Same as 1967
1971	Same as 1967	Same as 1967
1972	Same as 1967	Same as 1967 except a closed area between the Kenai River ferry crossing and a marker 500 yards upstream on Russian River, closed to all fishing June 1-30.
1973	Any fish hooked elsewhere than in the mouth must be released immediately.	Closed area at ferry crossing remains in effect June 1-30. Fly-only area extended from 500 to 1,800 yards below Kenai/Russian River confluence.
1974	Same as 1973	Closure between ferry crossing and marker 500 yards upstream on Russian River effective June 1-July 14.
1975	Unlawful to snag or attempt to snag. Snagging per se now unlawful.	Closure at confluence extended from below ferry crossing to a marker 700 yards upstream on Russian River, June 1-July 14.

* In 1967 terminal gear was limited to one unweighted single hook fly with hook no larger than 3/8" from point to shank. Weights must be at least 18" in front of the fly. This regulation remains unchanged through 1975.

** Salmon fishing above a marker 600 yards below Russian River Falls prohibited since 1960.

Due to anticipated low returns of early run salmon in 1975, 1976, and 1977, the bag and possession limit was decreased from three to one salmon during the early run migrational period. Creel census data indicated this regulatory measure would reduce early run harvest rates by 41.2% (Nelson, 1975).

Despite an increasingly restrictive fishery, demands upon Russian River red salmon were at times greater than the resource could provide. This is evidenced in that the Sport Fish Division has closed all or part of the fishery on ten different occasions since 1969 (Table 2). Prior to this date, emergency closures were not deemed necessary.

Table 2. Emergency Closures Issued by the Sport Fish Division of the Alaska Department of Fish and Game Affecting the Russian River Red Salmon Sport Fishery, 1969-1975*.

Year	Closure Date	Total or Partial Closure	Days Closed**	Run Affected
1969	7/27-8/ 8	Total	13	Late
1970	7/ 4-7/23	Total	20	Early
	7/28	Total	24	Late
1971	7/ 8-7/30	Total	24	Early
	8/14	Partial***	7	Late
1972	Closure at confluence of Kenai and Russian River extended 14 days			Early
1973	Closure at confluence of Kenai and Russian River extended 14 days			Early
	7/ 5-7/14	Total	10	Early
1974	7/ 1-7/ 5	Total	5	Early
	7/31	Total	21	Late
1975	7/ 1-7/14	Total	14	Early
	8/13	Total	8	Late

* No emergency closures affecting this fishery were issued prior to 1969.

** When the fishery was closed for the remainder of the season, it was assumed the season ends on August 20.

*** Fishery closed upstream from the Homer Electric Power Line, a distance of approximately 1.5 miles to protect fish experiencing difficulty negotiating Russian River Falls.

Management efforts are currently directed toward "in season" evaluation of stock status and analysis of fisheries statistics to determine the effectiveness of regulatory practices. Research efforts currently emphasize collection and evaluation of life history data. Objectives include determination of optimum escapement goals for both runs and ultimately, predictions of future returns to Russian River drainage. The latter goal will not be achieved until a smolt weir is constructed at Lower Russian Lake and a means of determining the late run's contribution to the Cook Inlet commercial fishery is developed.

Life history investigations of early run red salmon are presently confined to Upper Russian Creek, the only spawning area utilized by this run. Annual escapement counts are conducted to determine spawner distribution in the stream. Potential egg deposition is estimated employing fecundity/mortality data. Actual egg deposition investigations involve sampling various areas of the creek with an hydraulic sampler. Egg survival to the "eyed" stage is also calculated and, when feasible, eggs retained per female determined.

Late run investigations are directed toward determining numbers of red salmon which utilize respective spawning areas of Upper Russian Lake. This is accomplished by ground counts and, since 1973, by temporary weir on the largest tributary (Bear Creek) utilized by late run fish. Egg densities and survival are determined and pertinent climatological data are collected and analyzed.

RECOMMENDATIONS

1. Early run limit of one fish daily or in possession should be retained. Data collected in 1975 indicate it effectively reduced harvest. Returns for 1976-77 are expected to be below average and require increased protection.

2. Spawning ground investigations of early and late run spawning escapements should be confined to ground surveys of various spawning areas and determination of egg deposition. Bear Creek investigations will necessarily be limited as data suggest virtually no return to this stream in 1976.

3. Continue fecundity investigations at Lower Russian Lake weir.

4. Modify the existing weir at Lower Russian Lake to permit red salmon smolt enumeration.

5. Construct a fishway at Russian River Falls to prevent delay of migrating salmon.

OBJECTIVES

1. To determine abundance and migrational timing of adult red salmon in the Russian River Drainage.

2. To determine age composition of adult red salmon.

3. To determine sport harvest of adult early and late run Russian River red salmon.

4. To determine spawning areas utilized by late run red salmon in Upper Russian Lake drainage, the numbers of fish which utilize these respective areas, and the average stream life of salmon in these areas.

5. To determine egg and fry deposition for early and late run salmon in various areas of Upper Russian Lake.

6. To determine if a correlation exists between egg densities, percent viable egg to fry as opposed to the numbers of fish which spawned in a given area.

7. To determine the fecundity of early and late female red salmon and to determine the relationship between body weight, skein weight, and the number of eggs per skein.

8. To determine if late run red salmon destined for a small spring-fed tributary in Upper Russian Lake (Bear Creek) may be induced to spawn in the shoal area of that lake.

9. To determined if a correlation exists between climatological parameters as opposed to migrational timing, spawning period, and spawning success.

10. To evaluate current regulation on the sport fishery and to provide recommendations for future management and research.

TECHNIQUES USED

The 1975 Russian River creel census was a modification of the method described by Neuhold and Lu (1957). Sampling procedures were identical to those outlined by Engel (1965, 1970, 1972), and Nelson (1973, 1975).

Escapements were enumerated by weir at the outlet of Lower Russian Lake. The weir was constructed in June, 1975 and replaced a temporary structure previously described by Engel (1970).

The present weir was prefabricated in Palmer and transported by State owned amphibious aircraft to the weir site at Lower Russian Lake. Estimated weight of the structure exceeded six tons. The weir is located 75 feet below the old weir site, or approximately 125 yards downstream from Lower Russian Lake. It is 130 feet in length and at a 60° angle to the current. The stream bed was leveled and gravel replaced by rock-filled Reno mattresses to prevent scouring. Banks are stabilized by an arrangement of gabions to which the weir structure is attached. Rock for gabions and Reno mattresses was obtained from lake shore and transported via skiff.

The weir is secured to the stream bed by 20'3" x 5' steel pipes. Pipe was hand driven to a depth of approximately 4.5 feet. Each pair of pipes is connected by 5'9" stringers constructed from 4" x 6" timbers. To these stringers are attached steel tripods. Tripods are connected at top and base by 6" x 6" stringers 12 feet in length. These stringers support the weir panels, constructed of 3/4" O.D. aluminum tubing spaced 1.5" (center to center) apart. Overall panel dimensions are 2'6" x 5'6".

The trap and holding pen are constructed of 1" planks and are located on the west bank adjacent to the gabions. The trap is 4' x 5'. The holding pen is adjacent to the trap and is connected by a gate. The holding pen dimensions are 5' x 6'. 1/

Weir construction began on June 6 and required 20 calendar days (130 man-days) to complete. The structure was a total barrier to salmon migration on June 25. Total cost (construction plus installation) was approximately $24,000.

Fecundity investigations were again conducted at Russian River weir. Methodology of egg enumeration by volumetric estimation has been described (Nelson, 1975).

Scale samples from early and late run salmon were collected at Lower Russian Lake weir. Scales were impressed on cellulose acetate and read on a Bruning 200 microfiche projector. Age designation is expressed by the European formula as discussed by Koo (1962).

A temporary weir was constructed at the mouth of Bear Creek (Upper Russian Lake) on September 8. The weir was designed to allow enumeration of all adult salmon entering the stream. Weir construction was identical to that employed at Upper Russian Creek in 1972 (Nelson, 1973).

Salmon were tagged at the Bear Creek weir to determine stream life. Serially numbered red Floy tags were employed. Application of these tags has been previously described (Nelson, 1975). Tag recovery was effected by daily ground surveys above the weir.

Late run red salmon spawning in Upper Russian Lake tributaries and between Upper and Lower Russian lakes were enumerated by ground surveys. Methodology to calculate estimated spawning population in Upper Russian Lake proper has been previously described by Nelson (1975).

1/ Detailed weir plans are on file at the Soldotna office of the Alaska Department of Fish and Game.

Late run female carcasses were opened for egg retention determinations in conjunction with spawning ground surveys. Method(s) of enumerating retained eggs have been previously described (Nelson, 1974).

Egg density in Bear and Upper Russian creeks was determined by hydraulic sampler patterned after equipment described by McNeil (1964). Sampling technique in both areas was similar to prior years and has been described (Nelson, 1973, 1975).

Total eggs deposited by early and late run salmon in Bear and Upper Russian creeks was determined by direct and indirect methods. Application of these methods has been described (Nelson, 1975).

Samples to determine the presence or absence of the viral disease infectious hematopoietic necrosis (IHN) were taken from early run fish in Upper Russian Creek and late run Bear Creek salmon. Salmon were captured by 50' beach seine.

Water and air temperatures at both Lower and Upper Russian lakes were determined by Taylor maximum/minimum thermometer. Stream depth at Lower Russian Lake weir was determined by meter stick affixed to a steel post. This allowed a determination of relative stream fluctuations throughout early and late run migrations. Temperature and stream depth observations were recorded at 10 a.m. daily.

FINDINGS

Results

Creel census to evaluate management/regulatory measures and to determine harvest and effort was in effect from June 14 to July 1 and from July 15 to August 12. All angling effort directed toward red salmon stocks was sampled. Census data indicated anglers expended 16,510 man-days of effort or 74,529 angler hours in 1975. Effort directed toward early and late run stocks was estimated at 5,210 and 11,300 man-days, respectively.

Based on interviews with 1,684 anglers who reported harvesting 1,098 red salmon, total catch was estimated at 9,790 red salmon. Early and late runs contributed 1,400 and 8,390 salmon, respectively, to this harvest. Mean hourly early and late run success rates were higher on weekdays (0.145) than on weekend days (0.136) due to greater angler congestion during weekend periods. Harvest, effort and catch per hour estimates since 1963 are summarized in Table 3.

Table 3. Red Salmon Harvest, Effort and Success Rates on Russian River, 1963-1975.

Year	Harvest Early Run	Late Run	Total	Effort (man-days)	Catch/ Hour	Census Period
1963	3,670	1,390	5,060	7,880	0.190	6/ 8-8/15
1964	3,550	2,450	6,000	5,330	0.321	6/20-8/16
1965	10,030	2,160	12,290	9,730	0.265	6/15-8/15
1966	14,950	7,290	22,240	18,280	0.242	6/15-8/15
1967	7,240	5,720	12,960	16,960	0.141	6/10-8/15
1968	6,920	5,820	12,740	17,270	0.134	6/10-8/15
1969	5,870	1,150	7,020	14,930	0.094	6/ 7-8/15
1970	5,750	600	6,350	10,700	0.124	6/11-7/27*
1971	2,810	10,730	13,540	15,120	0.192	6/17-8/20**
1972	5,040	16,050	21,090	25,700	0.195	6/17-8/21
1973	6,740	8,930	15,670	30,590	0.102	6/ 9-8/19***
1974	6,440	8,500	14,940	21,120	0.131	6/ 8-7/30****
1975	1,400	8,390	9,790	16,510	0.140*****	6/14-8/13
1963-1974 Average	6,384	5,899	12,483	16,134	.178	

* Census active from June 11-July 3 and from July 24-July 27.
** Census active from June 17-July 7 and from July 31-August 20.
*** Census active from June 9-July 4 and from July 15-August 19.
**** Census active from June 8-June 30 and from July 6-July 31.
***** Catch/hour computed on data collected when fishery was open and fish were present. Data collected from July 15-July 24 when fishery was open and fish were not present is not included in calculations.

Total angler effort decreased 21.8% compared to 1974 estimates and was 46.0% less than the record effort recorded in 1973. Reduced effort is attributed to reduction in bag and possession limit from three to one red salmon during the early run and extensive emergency closures during periods of both runs. Emergency closures were in effect 21 days (31.3%) out of an estimated 67 day season, which effectively reduced both harvest and effort.

Total weekday and weekend stream counts during 1975 averaged 65.0 and 149.6 anglers, respectively. Weekend counts are the third highest recorded. Weekday counts are the lowest recorded since 1969 and are 14.4% lower than the historical average. Limited angler participation during the early run is evident as weekday counts during this period averaged 49.5. Weekend angler counts ranged from 31 to 290, averaging 116.5. Counts also reflect increased angling pressure on late run stocks. Weekday counts averaged 104.5. Weekend angler counts ranged from 109 to 314, averaging 228.3.

Each angler fished an average of 4.5 and 5.1 hours on weekdays and weekends, respectively. These figures are comparable to historical data. Fisheries statistics since 1964 are presented in Table 4.

Table 4. Differences Between Weekday and Weekend Day Fishing Pressures and Rates of Success at Russian River, 1964-1975.

Year	Angler Counts		Catch/Hour		Average Hours Fished	
	Week-days	Weekend Days	Week-days	Weekend Days	Week-days	Weekend Days
1964	29.6	70.6	0.444	0.209	3.3	3.9
1965	31.7	78.1	0.305	0.223	4.5	5.4
1966	53.2	143.1	0.297	0.183	4.8	5.5
1967	68.9	110.5	0.171	0.100	5.3	5.4
1968	71.5	124.9	0.153	0.107	5.3	5.8
1969	64.5	111.7	0.110	0.074	4.9	5.1
1970	83.5	127.8	0.140	0.100	4.8	4.7
1971	87.9	157.2	0.194	0.189	4.8	5.3
1972	73.3	138.5	0.203	0.187	4.0	4.4
1973	147.1	195.0	0.113	0.088	4.8	5.5
1974	123.8	144.4	0.164	0.085	4.7	5.7
1975	65.0	149.6	0.145	0.136	4.5	5.1
1964-1974 Average	75.9	127.4	0.209	0.140	4.7	5.1

Stream counts revealed 37.3% and 72.2% of the anglers enumerated during total stream counts fished the confluence area of Kenai and Russian Rivers during early and late runs, respectively. Distribution during the early run fishery was similar on weekdays and weekends. Anglers fishing late run stocks favored the confluence area on weekends (76.6%) and concentrated their efforts on the clear waters of Russian River during weekdays (56.3%).

The tendency for anglers to concentrate their efforts on Russian River during the early run migration is probably related to small numbers of early run salmon. As the 1975 early run was small and all fish entered the fishery in a short period of time, fishing success below the ferry crossing was excellent for a few days, then rapidly declined. Anglers then moved upstream to intercept the run as it left the protection of the closed area. The sanctuary area was opened during late run migration, increasing area available to sport anglers at the confluence. A closure was in effect during the latter portion of the run when fish were present in Russian River. This undoubtedly contributed to angler emphasis at the confluence during the late run migration.

During the census, 28 Dolly Varden, and 11 rainbow trout, were creel checked incidental to red salmon. These observations were expanded, revealing an estimated harvest of 225 Dolly Varden and 85 rainbow trout. One round whitefish, Prosopium cylindraceum (Pallas), was also observed as were three coho salmon. Silver salmon did not enter the fishery until August 11, two days prior to closure of the red salmon fishery and termination of the census. It is assumed that had the red salmon fishery remained open and the census been continued, harvest of this species would have been appreciable as coho salmon escapement was the highest recorded. No pink salmon were recorded during the census. Observation following the close of the red salmon fishery indicated few pink salmon in Russian River. Harvest of this species is assumed to be negligible.

Escapement:

The first early run red salmon was harvested June 14 at the ferry crossing. Salmon did not reach the weir until June 25. Early run escapement levels lagged below historical levels during the first 18 days of the fishery and the fly-only area was closed to red salmon fishing July 2. It was not reopened until July 15 when all early run salmon had passed the weir.

Late run salmon did not enter the fishery in appreciable numbers until July 25. Escapement levels suggested a smaller than average run was in progress. The fishery was therefore closed on August 13 and not reopened until all late run salmon had passed the weir.

The weir was operational June 25, 1975. Early run salmon were passed on this date, 12 days later than in 1974 and five days later than the historical arrival date of the run: June 20. Fifty percent of the escapement had passed the site by July 6, two days later than the historical average during years of weir operation (Nelson, 1975). Early run passage was complete by July 27.

Early run red salmon escapements average 11,400 (1963-1974) and have ranged from 2,650 (1971) to 21,510 (1965). Escapement in 1975 was 5,640, or 50.5% less than the historical average. As scale analysis indicates these salmon are primarily six-year fish, total run (harvest plus escapement) was 3,830 less than total parent year return of 10,870. Russian River early and late run escapements and harvest rates since 1963 are summarized in Table 5.

Table 5. Russian River Red Salmon Escapement Estimates and Harvest Rates for Early and Late Runs, 1963-1975.

	Escapement			Percentage of Run Caught by the Sport Fishery*		
Year	Early Run	Late Run	Total	Early Run	Late Run	Combined
1963	14,380	51,120	65,500	20.3	2.0	7.2
1964	12,700	46,930	59,630	21.8	5.0	9.6
1965	21,510	21,820	43,330	31.8	9.0	21.6
1966	16,660	34,430	51,090	47.3	17.5	30.3
1967	13,710	49,480	63,190	34.6	10.3	17.0
1968	9,200	48,880	58,080	42.9	10.6	18.0
1969	5,000**	28,920	33,920	54.0	3.8	17.1
1970	5,450	28,200	33,650	51.3	2.1	15.9
1971	2,650	54,430	57,080	51.5	16.4	19.2
1972	9,270	79,000	88,270	35.2	16.8	19.3
1973	13,120	24,970	38,090	33.9	26.3	29.1
1974	13,150	24,650	37,800	32.9	25.6	28.3
1975	5,640	31,970	37,610	19.9	20.8	20.7
1963-1974 Average	11,400	41,069	52,469	38.1	12.1	19.4

* Based on escapement past weir; commercial harvest and fish spawning downstream from Russian River weir are not considered.

** Escapement determined by foot survey of Upper Russian Creek.

Anglers harvested 20.8% of the late run (exclusive of fish spawning below the falls) to reach Russian River. This is an increase over the 12-year mean of 12.1%.

Late run Russian River escapements have ranged from 21,820 (1965) to 79,000 (1972), averaging 41,063. The 1975 escapement was 31,970. A ground survey between Russian River Falls and the confluence of the Kenai and Russian rivers revealed an additional 690 salmon spawning in this area (Table 6).

Table 6. Red Salmon Escapements Enumerated Between Russian River Falls and Confluence of Kenai and Russian Rivers, 1968-1975.

Year	Escapement Below Falls	Total Late Run*	Percent of Total Return
1968	4,200	58,900	7.1
1969	1,100	31,170	3.5
1970	222	29,022	0.8
1971	10,000	75,160	13.3
1972	6,000	101,050	5.9
1973	6,685	40,585	16.5
1974	2,210	35,360	6.3
1975	690	41,050	1.7
1968-1974 Average	4,345	53,035	7.6

* Includes sport harvest, fish spawning below Russian River Falls and escapement enumerated at Lower Russian Lake weir.

This count is one of the lowest recorded as the 1968-1974 average spawning escapement below Russian River Falls is 4,345. Total late run escapement to Russian River drainage is therefore estimated at 32,650 red salmon.

Sport anglers harvested 19.9% of early run salmon to reach Russian River. This is a reduction of 47.7%, compared to the historical mean harvest rate of 38.1% and is appreciably less than the 1969-1971 catch rate when over 50% of the run was harvested. Other factors contributing to reduced early run harvest rates have been discussed by Nelson (1973).

Percentages of the late run harvested by Russian River sport fishermen are useful as an index, but probably do not represent true harvest rates. Salmon migrating through the glacial Kenai River tend to school at the confluence area prior to entering Russian River or continuing on to spawning areas in Upper Kenai River drainage. Undoubtedly some of the salmon included in the Russian River harvest are of Kenai River origin (Engel, 1967).

Table 7 indicates prior to 1971 angler effort was directed toward early run stocks. From 1971-1973 over 50% of the effort was directed toward more numerous late run fish. In 1974 over 50% of the effort was again directed toward early run salmon. In 1975, 68.4% of all angler effort was directed toward late run stocks. This is the highest percentage of Russian River anglers to fish this run since the inception of these investigations in 1963. This trend is expected to continue and is a result of restrictive bag and possession limits in effect during the early run, as well as angler realization that more numerous late run fish are more readily captured.

Table 7. Angler Effort Directed Toward Early and Late Run Russian River Red Salmon Stocks, 1963-1975.

Year	Effort (man-days)		Effort (Percent)	
	Early Run	Late Run	Early Run	Late Run
1963	5,710	2,170	72.5	27.5
1964	3,980	1,350	74.7	25.3
1965	7,750	1,970	79.7	20.3
1966	11,970	6,310	65.5	34.5
1967	11,460	5,500	67.6	32.4
1968	11,780	5,500	68.2	31.8
1969	12,290	2,640	82.3	17.7
1970	9,700	1,000	90.7	9.3
1971	6,250	8,870	41.3	58.7
1972	12,340	13,360	48.0	52.0
1973	15,220	15,470	49.6	50.4
1974	11,090	10,030	52.5	47.5
1975	5,210	11,300	31.5	68.4
1963-1974 Average	9,962	6,181	66.1	33.9

Early Run Return/Spawner and Optimum Escapement Estimates:

Table 8 indicates a range of 0.3-2.1 fish returning per spawning adult in parent year early run escapements. It is of interest to note that in the six years under consideration, lowest return per spawner was produced from the greatest escapement (21,510 in 1965). The highest return of 2.1 salmon per spawning adult resulted from a parent year escapement of 9,200. Above average returns per spawner were also achieved from escapements of 13,710 and 5,000 early run red salmon.

Table 8. Estimated Production from Prior Escapements of Early Run Russian River Red Salmon, 1963-1969.

Brood Year	Escapement		Return (Year)	Total Run**	Production	
	Females*	Total			Per Female	Per Spawner
1963	7,190	14,380	1969	10,870	1.5	0.7
1964	6,350	12,700	1970	11,200	1.8	0.9
1965	10,755	21,510	1971	5,460	0.5	0.3
1966	8,330	16,660	1972	14,310	1.7	0.9
1967	6,855	13,710	1973	19,860	3.0	1.4
1968	4,600	9,200	1974	19,590	4.3	2.1
1969	2,500	5,000	1975	7,040	2.8	1.4
Average	6,654	13,309		12,619	2.2	1.1

* Assumes male to female sex ratio of 1:1.
** Harvest plus escapement. Assumes negligible commercial harvest.

Although not definitive, data in Table 8 suggest large escapements do not necessarily produce large returns. Above average returns per spawner from a low escapement (1969) similarly will not produce enough salmon to support the Russian River sport fishery. In 1973 and 1974 total return to Russian River exceeded 19,000 early run salmon. These returns were produced by escapements of 13,710 and 9,200 salmon.

Spawning area in Upper Russian Creek (only spawning area utilized by early run salmon) approximates 13,800 M^2. Studies by other investigators (summarized by Foerster, 1968) indicate area required per red salmon female ranges from 2.0-3.7 M^2. For calculation purposes, it is assumed that 2.67 M^2 (average of other investigations) is required per female in Upper Russian Creek. This would require an escapement of approximately 5,170 females or, assuming a 1:1 sex ratio, 10,340 early run salmon. Although speculative, returns from a known spawning population coupled with analysis of spawning area suggest optimum early run escapement is between 9,000 and 13,000 salmon.

Although optimum early run escapement levels may fall between the above ranges, it must be recognized that factors other than escapement influence returns from a given spawning population. Adverse climatic conditions, i.e., low water, temperature extremes, may adversely affect developing eggs and fry. An unbalanced sex ratio coupled with fluctuations in average fecundity will result in relatively high or low egg deposition irrespective of numbers of salmon in the spawning population. Predation may not be constant during years of freshwater residency and available plankton may fluctuate in abundance. Fry density of late run fish in the nursery lake may also affect survival rates. Ocean mortality may not be constant and predation on the spawning grounds may fluctuate annually. It can therefore be concluded that despite achievement of escapement goals returns per spawning adult will display annual fluctuation and that these fluctuations may be independent of the number of spawners in the parent year escapement.

Relationship of Jacks to Adults:

No precocial males (jacks) were observed during the 1975 early run migration. Jacks are present in the late run comprising between 0.2-8.8% of the escapement (1969-1975). Late run harvest, escapement, total return, and number of returning jacks since 1969 is presented in Table 9.

Table 9. Late Run Russian River Red Salmon Harvest, Escapement and Returning Jacks, 1969-1975.

Year	Escapement	Harvest	Total Return*	Number of Jacks	Percent of Total Return
1969	28,920	1,150	30,070	352	1.2
1970	28,200	600	28,800	2,542	8.8
1971	54,430	10,730	65,160**	1,429	2.2
1972	79,000	16,050	95,050	160	0.2
1973	24,970	8,930	33,900	332	1.0
1974	24,650	8,500	33,150	1,008	3.0
1975	31,970	8,390	40,360	1,788	4.4

* Excludes commercial harvest and salmon spawning below Russian River weir.

** Excludes an estimated 10,000 salmon which perished below Russian River Falls due to a velocity barrier.

Table 9 suggests that numbers of jacks returning in a given year may reflect run magnitude the following year. In 1969, 1972, and 1973 jack escapements were less than 500. Escapements of respective succeeding years (1970, 1973, 1974) were among lowest recorded, averaging 25,940 or 35.7% less than the 13-year mean (40,369). Conversely, jack escapement in 1970, 1971, and 1974 exceeded 1,000 fish. Escapements in 1971 and 1972 were the highest recorded at Russian River, averaging 66,715 salmon, or 65.3% greater than the 13-year mean. Escapement in 1975 was 31,970. This was relatively low in view of the relatively large jack escapement (1,008) in 1974. Return to Russian River, however, was the third largest recorded since 1969.

Table 10 presents adults per jack based on the preceding year's jack escapement. This table indicates a range of 25.6 to 211.9 adults for every jack which returns to the system the preceding year. Range for years of low escapement (1970, 1973, 1974) are between 81.8 and 211.9, averaging 131.2 adults/jack. The range for two years of high escapement is 25.6 to 66.5, averaging 46.1 adults to one returning jack. In 1975, 40 adults returned for every jack enumerated in 1974.

Table 10. Late Run Red Salmon Adults Per Returning Jack as Calculated from Preceding Year's Jack Escapement, Russian River, 1969-1975.

Year	Total Return*	Preceding Year's Jack Escapement	Adults/Jack
1969	30,070	Unknown	Unknown
1970	28,800	352	81.8
1971	65,160**	2,542	25.6
1972	95,050	1,429	66.5
1973	33,900	160	211.9
1974	33,150	332	99.8
1975	40,360	1,008	40.0

* Excludes commercial harvest and salmon spawning below Russian River weir.

** Excludes an estimated 10,000 late run red salmon which perished below the Russian River Falls due to a velocity barrier.

It must be emphasized that although a general relationship appears to exist between numbers of jacks returning in a given year and magnitude of succeeding year's total return, predictions cannot be made regarding future runs. Parameters presently exist for which adequate compensation cannot be made. These have been discussed in detail by Nelson (1975).

It is also of interest to note the migrational timing of jacks as opposed to late run adults. Fifty percent of the adults have historically passed the weir at Lower Russian Lake by August 7. However, half the jack escapement does not pass weir site until approximately August 14, seven days later than the adults (Table 11).

Table 11. Migrational Timing of the Late Run Russian River Red Salmon Jack Escapement Compared to the Migrational Timing of the Adult Escapement, 1970-1975.

Year	Jack Escapement	Date 50% Passed	Adult Escapement	Date 50% Passed	Timing Differential (Days)
1970	2,542	8/10	25,658	8/ 7	4
1971	1,429	8/28	53,000	8/23	6
1972	160	8/10	78,677	8/ 4	7
1973	332	8/ 6	24,642	7/31	7
1974	1,008	8/12	23,639	8/ 6	7
1975	1,788	8/16	30,179	8/ 5	12
Average	1,210	8/14	39,299	8/ 7	7

It is not known whether this timing differential is a racial characteristic or related to physical factors. Water levels decrease during the latter part of migration and may facilitate the jack's movement through the falls. Larger adults may be more readily capable of negotiating the barrier at greater velocity levels and thus arrive earlier at the weir.

Migrational Timing of the Late Run in Kenai River:

A summary of migrational timing of both red salmon runs within the Russian River drainage has been presented by Nelson (1975). Limited data, however, are available regarding that period of migration which occurs within the mainstem Kenai River. Only data available are from the Alaska

Department of Fish and Game's sonar counter operated by the Commercial Fish Division, and limited tagging experiments conducted by Fish and Wildlife Service and Department of Fish and Game.

The sonar counter is located approximately one mile below the Soldotna bridge and is operational only during late run migration. It is approximately 58 river miles from sonar site to weir. The counter has been used to enumerate Kenai River red salmon escapements since 1968. Sonar counts, late run Russian River escapements, dates when 50% of run has passed the sonar site/weir, and period of travel between sonar site and weir, are presented in Table 12.

Table 12. Kenai River Sonar Counts Compared to Russian River Late Run Escapements and Period of Travel Between Sonar Site and Russian River Weir, 1968-1975.*

Year	Sonar Count**	Date 50% Passed	Russian River Escapement***	Date 50% Passed	Sonar to Weir (Days)
1968	87,000	7/19	48,880	7/30	11
1969	42,000	6/30	28,920	8/ 2	34
1970	61,000	7/25	28,200	8/ 6	13
1972	267,000	7/24	79,000	8/ 4	12
1973	363,000	7/22	24,970	7/31	10
1974	178,000****	7/16	24,650	8/ 6	22
1975	162,000*****	7/24	31,970	8/ 5	13
1968-1974 Average	166,333	7/17	39,103	8/ 3	17

* 1971 deleted due to sonar failure.
** All counts represent red salmon counts. Counts begin on 6/20.
*** Escapement reflects weir counts only and is exclusive of fish spawning in lower Russian River.
**** Sonar counts for 1974 have been revised down to 178,000 from the previously reported 195,000.
***** Preliminary data.

Table 12 indicates elapsed time between sonar site and weir has ranged from 10 to 34 days, averaging 17 days. Eliminating the 1969 extreme, migrational period ranges from 10-22 days, averaging 13.5. It required 13 days for Russian River fish to migrate the estimated 58 miles in 1975, or an average of 4.5 miles per day.

Tagging experiments were conducted by Tait, et al (1962) in 1957 to assess migrational timing and distribution of Kenai River stocks. Based on 106 tag recoveries at the confluence of the Kenai and Russian rivers, they concluded the average red salmon required approximately 20 days to traverse the estimated 65 miles from tagging location to point of capture in the sport fishery, or an average of 3.3 miles/day.

Similar experiments were conducted by Davis (1971) in 1970, and in 1972 and 1973 by Davis, et al (1973, 1974). Data from the 1970 experiment was basically in agreement with data presented in Table 13, indicating it required an average of 14.8 days for a Russian River red salmon to reach Russian River weir. Data from 1972 and 1973 experiments did not agree with data obtained from an evaluation of sonar/weir counts and indicated migrational time was between 18-30 days.

Reasons for these apparent disparities between travel time determined by tagging versus a comparison of sonar/weir counts are not definitely known but may be related to the following: (1) tag returns may have been insufficient to represent migrational time of the collective late Russian River run, (2) tagged fish may have experienced stress and migrated at a slower rate than untagged salmon, (3) sonar counts may have been inaccurate, (4) numbers of Russian River salmon may have been relatively low compared to Kenai River red salmon numbers and migrational timing obtained by sonar counter may represent timing of the latter stock, and (5) combination of any or all of the above may have contributed to discrepancies between tagging data and a comparison of sonar/weir counts.

Evaluation of sonar and Russian River harvest and escapement data does, however, provide an estimate of Russian River's contribution to Kenai River red salmon escapements. Data indicate average Russian River contribution ranges from 11.3-74.2%, averaging 43.2% annually (Table 13).

Percentages in Table 13 are dependent on: (1) accuracy of sonar counter, and (2) accuracy of 1968 Russian River tower count (weir was functional from 1969-1975). It was concluded that Russian River is the major contributor to the Kenai River system in an average year (Nelson, 1975).

Table 13. Kenai River Sonar Counts, Total Late Russian River Salmon Run, and Percent of Kenai River Red Salmon to Enter Russian River, 1968-1975.*

Year	Red Salmon Sonar Count**	Total Late Russian River Run***	Percent Kenai Run to Russian River
1968	87,000	59,520	68.4
1969	42,000	31,160	74.2
1970	61,000	28,800****	47.2
1972	267,000	102,120	38.2
1973	363,000	40,985	11.3
1974	178,000****	35,357	19.9
1975	162,000*****	41,050	25.3
1968-1974 Average	166,333	49,657	43.2

* 1971 data was deleted due to sonar failure.
** Sonar counts have been apportioned and are considered red salmon counts only.
*** Includes escapement past weir, fish spawning below falls, and sport harvest.
**** Sonar counts for 1974 have been revised down to 178,000 from the previously reported 196,000.
***** Preliminary data.

A total of 102 king, O. tshawytscha (Walbaum) and an estimated 4,000 silver salmon were enumerated at Lower Russian Lake weir. An additional 32 chinook salmon were enumerated between weir and confluence of Kenai and Russian rivers. Annual chinook salmon escapements are comparable (Nelson, 1975) and indicate escapement of this species was 33.3% less than the historical six-year average (153). Silver salmon enumerated at the weir totaled 1,875. It was estimated that more than 2,000 silver salmon were below the weir when it was removed on September 1. Minimum escapement of this species is therefore estimated to be 4,000. This is the greatest escapement recorded at Russian River (Table 14).

Table 14. Silver and Chinook Salmon Escapements Enumerated at Russian River Weir, 1969-1975.

Year	Silver Salmon	Chinook Salmon	Weir Opened	Weir Closed
1969	70	119	June 21	August 19
1970	957	240	June 14	August 24
1971	839	21	June 23	September 8
1972	666	172	June 15	August 28
1973	200	243	June 14	August 30
1974	1,508	124	June 14	August 28
1975	4,000*	102	June 25	September 1
1969-1974 Average	707	153		

* As of September 1, 1975, 1,875 silver salmon had passed the weir. It was estimated that more than 2,000 silver salmon were below the weir when it was removed. Minimum escapement is therefore estimated at 4,000.

Age Composition:

Scale analysis indicated red salmon in their sixth year of life comprised 76.4% of the early Russian River run. Five-year fish comprised 21.5% of the sample. Remaining 2.1% of the salmon examined were either four or seven-year fish. This run was dominated by salmon which had resided two years in freshwater. Majority of these red salmon (76.4%) were progeny of the 1969 escapement.

Early run salmon averaged 588.3 mm in length. Average lengths of two- and three-ocean fish were 542.1 and 600.7 mm, respectively. Male to female sex ratio of the early run was 1:1.6.

Late run stocks were also dominated by salmon which migrated to the marine environment after two years in freshwater (89.8%). The majority of this run (68.8%) spent two years in salt water prior to returning in their fifth year. Majority of the salmon examined were progeny of the 1970 escapement. Male to female sex ratio of 282 adults (excluding jacks) was 1:0.9. Adults averaged 531.3 mm in length. Two-and three-ocean adults averaged 552.2 and 603.2 mm in length, respectively. Age class composition of early and late runs and mean lengths for respective age classes is presented in Table 15.

Table 15. Age Class Composition of Early and Late Run Russian River Adult Escapements Sampled at Lower Russian Lake Weir, 1975.

Age Class	No. in Sample	Percent of Sample	Parent Year	Average Length (mm)*	SD**
		EARLY RUN			
1.2	1	0.4	1971	560.0	
1.3	4	1.8	1970	600.0	8.2
1.4	1	0.4	1969	620.0	
2.2	45	19.7	1970	540.0	21.6
2.3	172	75.1	1969	600.4	22.4
2.4	1	0.4	1968	660.0	
3.2	2	0.9	1969	580.0	56.6
3.3	3	1.3	1968	616.7	11.5
		LATE RUN			
1.2	11	5.4	1971	535.6	20.3
1.3	6	2.9	1970	597.3	28.8
2.2	135	65.9	1970	552.3	42.2
2.3	49	23.9	1969	606.0	51.2
3.2	4	1.9	1969	582.0	48.8

* Length is from mid-eye to fork of tail.
** Standard deviation.

It is of interest to note mean lengths of both early and late run three-ocean salmon differed by only 2.5 mm. Mean length of two-ocean late run fish was 10.1 mm greater than two-ocean early run salmon. These minimal disparities in similar age salmon from different populations indicate similar growth rates during ocean residency. Differences in average size of salmon returning within a given run were therefore related to age structure of the respective population rather than differential growth rates between populations.

A length-frequency of fish sampled during the early run is presented in Figure 3. Although not definitive, this graph indicates a division of the populations between 560-569 mm. If the division were made here, it would indicate 22.5% and 77.5% of the population were two-and three-ocean fish, respectively. Table 15 supports this premise. Length-frequency analysis could be employed to determine ocean age in 1975. Whether it can be effectively utilized in future years will require further investigation.

Figure 4 presents length-frequency of two-and three-ocean early run red salmon as determined from scale analysis. This graph illustrates the ranges for these age classes and compared with Figure 3, indicates length ranges where three-ocean fish would be erroneously assigned a two-ocean age base on length alone.

Length frequency of 293 late run red salmon is graphically presented in Figure 5. This figure indicates appreciable variation in the lengths of individuals within this population. Tentative divisions are, however, suggested. It appears one-ocean jacks range from 370-419 mm; two-ocean fish from 430-599 mm; and three-ocean salmon from 600 to more than 639 mm. One, two, and three-ocean salmon would therefore constitute 9.4%, 69.1%, and 21.5% of the sample, respectively. Scale analysis supports this conclusion as it indicates the sample was composed of 12.0% one-ocean, 64.4% two-ocean; and 23.6% three-ocean salmon. Ocean ages of late run salmon could therefore be determined by length frequency in 1975.

Figure 6 depicts length frequency of one, two, and three-ocean late run salmon determined by scale analysis. It graphically depicts ranges of the respective ocean ages as well as the degree of overlap between lengths of one and two, as well as two-and three-ocean salmon. The graph suggests that the peaks in the frequency distribution do represent successive age groups, although the probability of determining age by length for a particular specimen may be low. This is particularly true in the overlap area of the peak of two-ocean salmon, and the low end of the three-ocean salmon distribution (510 to 600 mm).

Fecundity Investigations:

Fecundity investigations initiated in 1973 were continued at Russian River weir during early and late runs. Results are presented in Table 16 and 17.

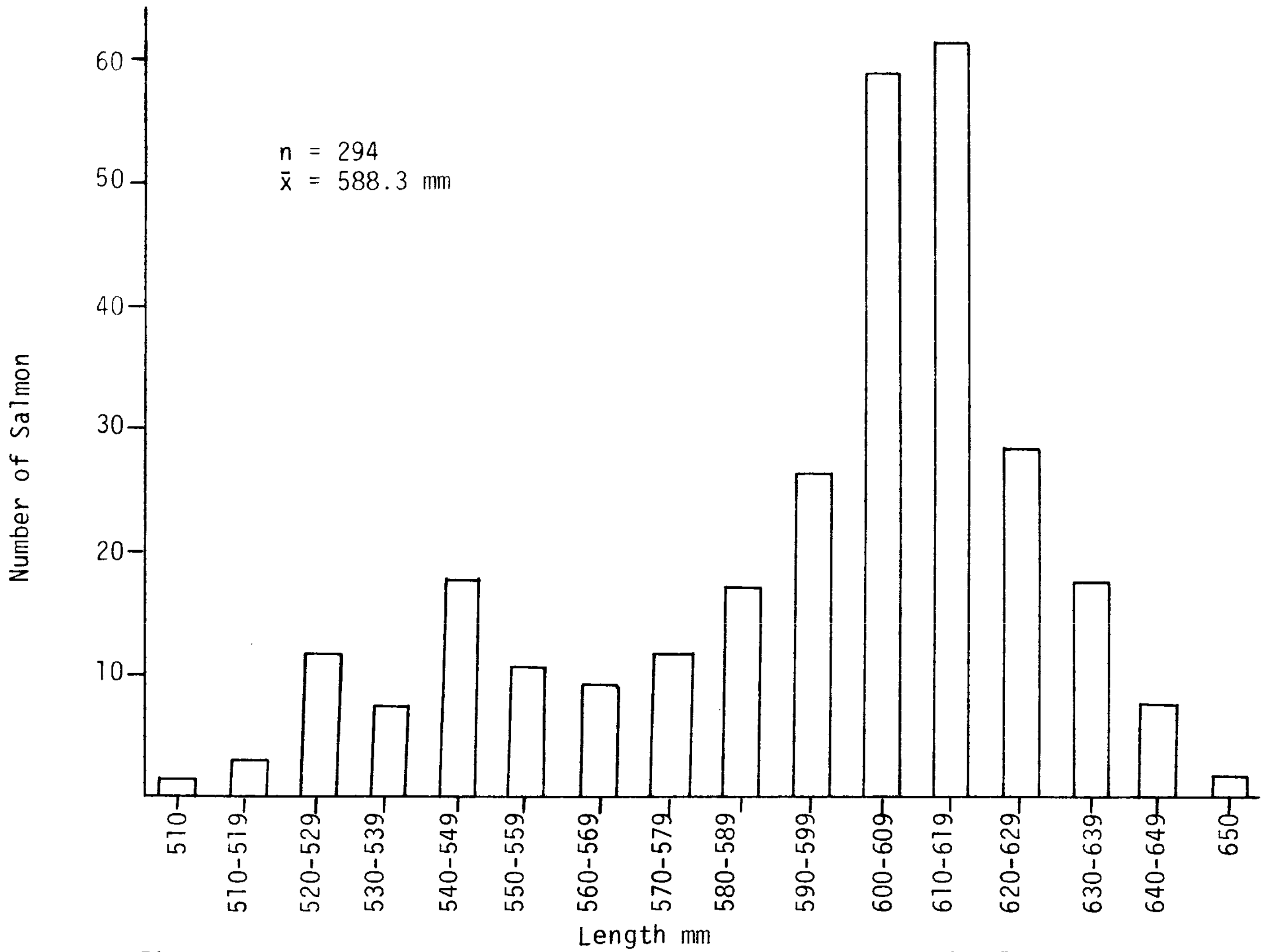

Figure 3. Length Frequency of Early Run Russian River Red Salmon Sampled at Lower Russian Lake Weir, 1975.

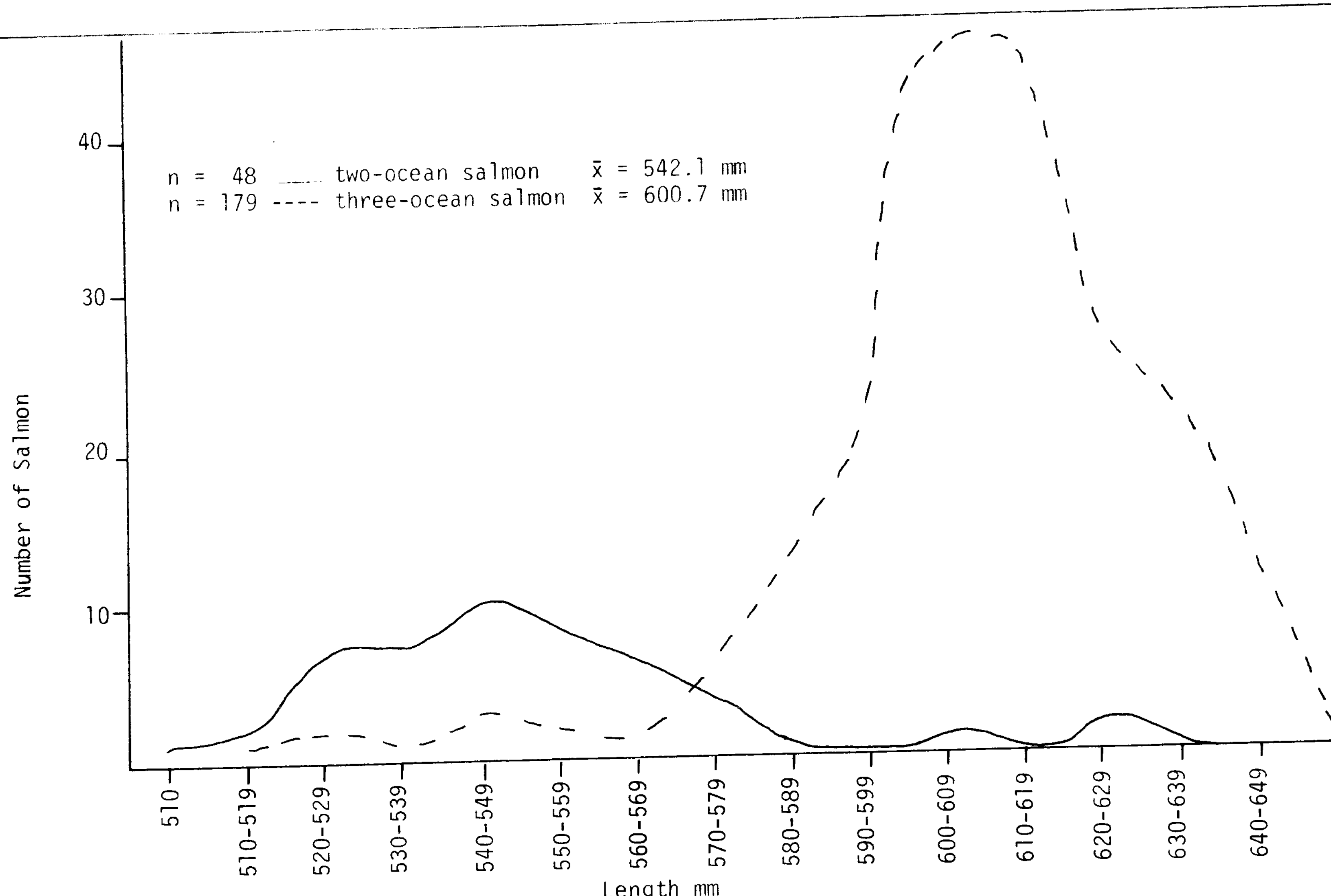

Figure 4. Length Frequency of Two and Three-Ocean Early Run Russian River Red Salmon Sampled at Lower Russian Lake Weir, 1975.

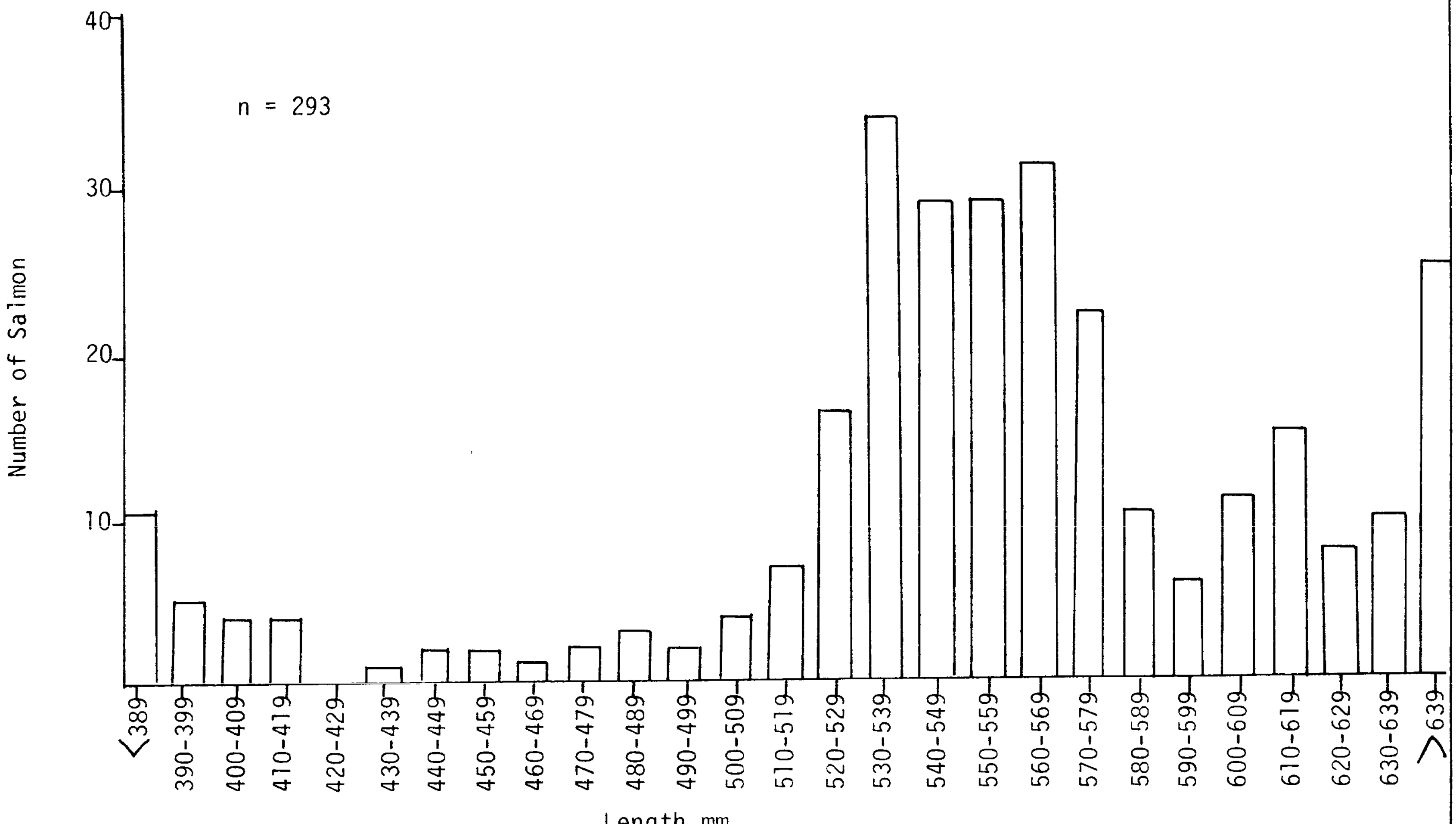

Figure 5. Length Frequency of Late Run Russian River Red Salmon Sampled at Lower Russian Lake Weir, 1975.

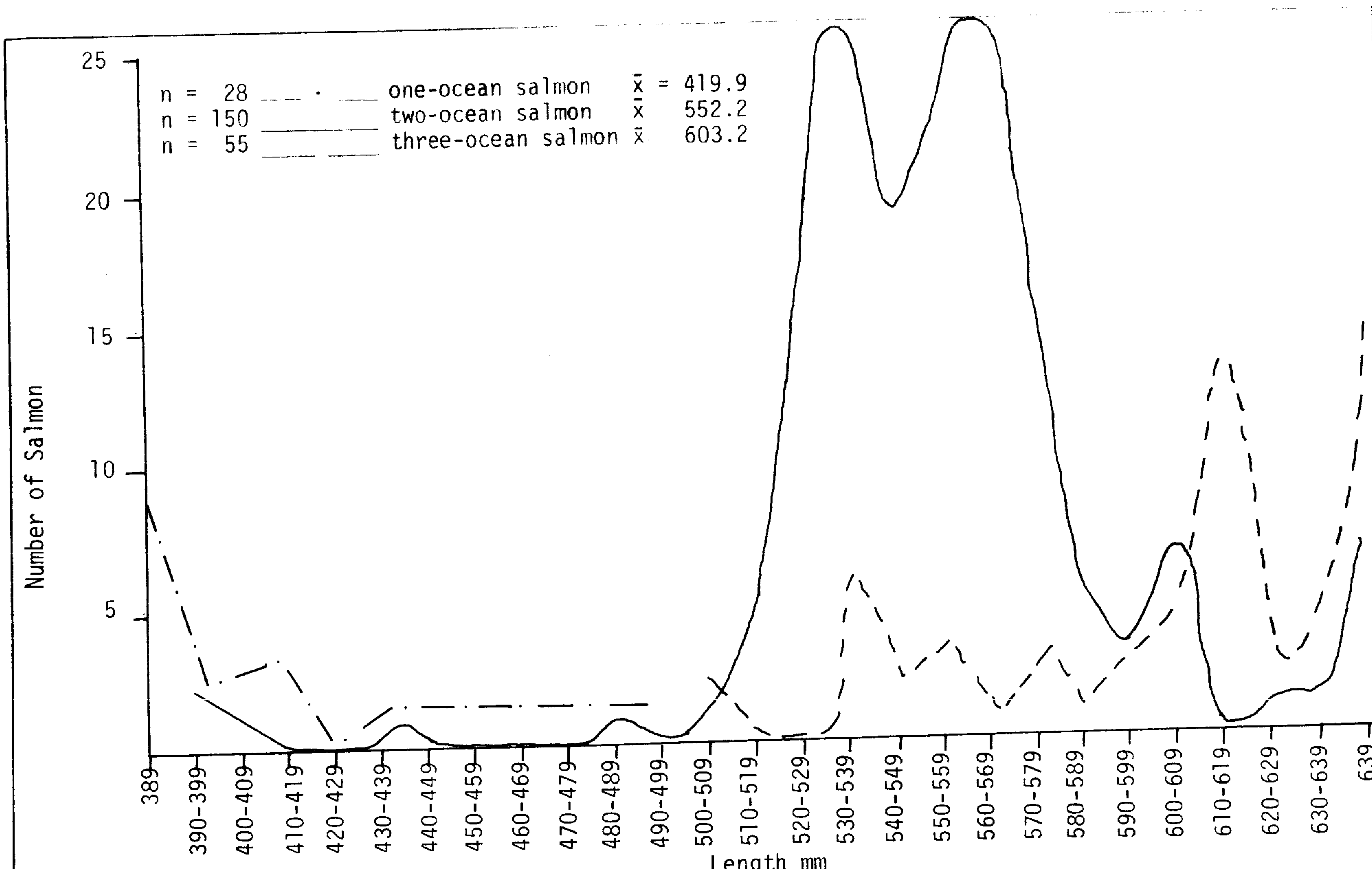

Figure 6. Length Frequency of One, Two and Three-Ocean Late Run Russian River Red Salmon Sampled at Lower Russian Lake Weir, 1975.

Table 16. Fecundity of Early Russian River Red Salmon as Determined by Actual Count and Volumetric Estimate, Lower Russian Lake Weir, 1975.

EARLY RUN

Sample Number	Weight (kg)	Age Class	Number of Eggs (Actual Count) Right Skein	Left Skein	Combined	Number of Eggs (Volumetric Estimate) Right Skein	Left Skein	Combined	Percent Error
1	2.837 (6.25 lb)	Unknown	2,170	2,280	4,450	2,211	2,223	4,434	0.36
2	2.610 (5.75 lb)	1.3				2,000	2,080	4,080	
3	2.383 (5.25 lb)	Unknown	1,620	1,828	3,448	1,620	2,008	3,628	-5.22
4	2.977 (6.56 lb)	Unknown				2,072	2,172	4,244	
5	2.837 (6.25 lb)	Unknown	2,030	2,260	4,290	1,950	2,212	4,162	2.98
6	1.929 (4.25 lb)	Unknown				1,504	1,610	3,114	
7	2.451 (5.40 lb)	Unknown	1,900	2,300	4,200	1,828	2,255	4,083	2.79
8	2.950 (6.50 lb)	Unknown				2,254	2,411	4,665	
9	2.383 (5.25 lb)	2.3	1,595	1,875	3,470	1,597	1,848	3,445	0.72
10	2.610 (5.75 lb)	1.3				1,760	2,046	3,806	
11	2.329 (5.13 lb)	Unknown	1,910	2,035	3,945	1,875	2,088	3,963	-0.46
12	2.183 (4.81 lb)	2.3				1,500	1,740	3,240	
Average	2.537 (5.59 lb)		1,870.8*	2,096.3*	3,967.2*	1,846.8*	2,105.7*	3,952.5*	0.19*

* Averages computed using samples 1, 3, 5, 7, 9, and 11 only.

Table 17. Fecundity of Late Russian River Red Salmon as Determined by Actual Count and Volumetric Estimate, Lower Russian Lake Weir, 1975.

LATE RUN

Sample Number	Weight (kg)	Age Class	Number of Eggs (Actual Count) Right Skein	Left Skein	Combined	Number of Eggs (Volumetric Estimate) Right Skein	Left Skein	Combined	Percent Error
1	2.269 (5.00 lb)	2.3	1,630	2,235	3,865	1,653	2,303	3,956	-2.35
2	2.555 (5.63 lb)	2.3				1,449	1,612	3,061	
3	2.769 (6.10 lb)	Unknown				1,650	2,240	3,890	
4	2.723 (6.00 lb)	Unknown	1,590	1,984	3,574	1,605	1,945	3,550	0.67
5	2.269 (5.00 lb)	2.2				1,620	1,784	3,404	
6	2.383 (5.25 lb)	2.2				1,633	1,833	3,466	
7	2.555 (5.63 lb)	2.2	1,835	1,850	3,685	1,800	1,793	3,593	2.50
8	2.769 (6.10 lb)	2.2				1,372	1,704	3,076	
9	2.496 (5.50 lb)	2.2				1,715	1,755	3,470	
10	2.678 (5.90 lb)	1.3	2,150	1,975	4,125	2,139	1,984	4,123	0.05
11	2.043 (4.50 lb)	1.2				1,428	1,411	2,839	
12	1.929 (4.25 lb)					905	1,039	1,944	
13	2.156 (4.75 lb)	2.3	1,785	1,825	3,610	1,742	1,840	3,582	0.77
14	1.8.6 (4.00 lb)					1,054	1,203	2,257	
15	2.043 (4.50 lb)	2.2				1,275	1,455	2,730	
16	2.156 (4.75 lb)	2.3	1,380	1,440	2,820	1,369	1,449	2,818	0.07
17	2.043 (4.50 lb)	2.2				1,175	1,924	3,099	
18	1.861 (4.10 lb)	2.2				1,101	1,398	2,499	
19	2.315 (5.10 lb)	2.2	1,750	1,550	3,300	1,738	1,522	3,260	1.21
20	1.702 (3.75 lb)	2.2				1,020	1,122	2,142	
21	1.861 (4.10 lb)	Unknown				1,309	1,294	2,603	
Average	2.257 (4.97 lb)		1,731.4*	1,837.0*	3,568.4*	1,720.9*	1,833.7*	3,554.6*	0.42*

* Averages computed using samples 1, 4. 7, 10, 13, 16, and 19 only.

Fecundity of early run salmon ranged from 3,114-4,665, averaging 3,952.5 eggs/female. Average weight and length of females sampled was 2.540 kg and 600.0 mm, respectively. These salmon averaged 1,556.1 eggs per kilogram of body weight and 6.6 eggs per millimeter of body length. Late run fish averaged 3,554.6 eggs/female with a range of 1,944-4,123 eggs/female. Average length and weight was 555.0 mm and 2.257 kg, respectively. These fish averaged 1,574.9 eggs per kilogram of body weight and 6.4 eggs per millimeter of body length. Table 18 compares these results with investigations in 1973 and 1974.

In all years under consideration, average egg content of larger early run females exceeded that of smaller late run salmon. This supports the conclusion of Foerster (1968) in that positive correlation is established between fish size and egg content.

In 90.9% of the fish sampled, the left ovary contained a greater number of eggs than did the right ovary. As indicated by Rounsefell (1957), the probable explanation of this phenomenon was advanced by Brown and Kamp (1942). They indicated the posterior portion of the intestine usually bends strongly to the right, crowding the right ovary at the caudal end. The left ovary therefore has greater room for expansion and contains more eggs. This has also been documented by Hartman and Conkle (1960) in fecundity investigations of Brooks Lake (Alaska) red salmon. Although it appears generally true that the left ovary contains more eggs than the right, exceptions do exist. Nelson (1959) reported the opposite condition for red salmon in Bare Lake, Alaska, i.e., more eggs in the right ovary than the left ovary.

It is of interest to note, however, that in 1975 the average early run female was somewhat smaller than in 1974, yet contained a greater number of eggs. This also occurred in the late run sample as these fish were larger in 1974 than 1975, but average egg content of the smaller salmon exceeded that of the larger salmon. This apparent disparity, which would tend to question the validity of the conclusion that the larger the fish the greater the egg content, was also noted by Foerster (1941). He observed that certain variations occur in the relationship from year to year. In the case of Cultus Lake samples, the increase in number of eggs per centimeter rise in length varied from 77 (1937) to 157 (1938). Change in number of eggs per kilogram ranged from 1,004 (1937) to 1,490 (1938). He concluded these differences were not statistically significant but the result of inherent variability of the samples.

Table 18. Comparison of Fecundity Data Collected at Lower Russian Lake Weir During Early and Late Run Russian River Red Salmon Migrations, 1973-1975.

Year	Average Fecundity	Average Length (mm)	Average Weight (kg)	Eggs/ Kilogram	Eggs/ Millimeter
			EARLY RUN		
1973	4,630.0	627.0	2.968	1,560.0	7.4
1974	3,569.3	603.0	2.603	1,371.0	5.9
1975	3,952.5	600.0	2.540	1,556.1	6.6
			LATE RUN		
1973	3,190.0	569.0	2.187	1,458.6	5.6
1974	3,261.4	558.0	2.301	1,417.4	5.8
1975	3,554.6	555.0	2.257	1,574.9	6.4

In early run Russian River samples the number of eggs per centimeter of body length have ranged from 59-74. During the late run this variation has been somewhat less, i.e., from 56-64. Variation in number of eggs per kilogram ranges from 1,371.0-1,560.0 during the early run and from 1,417.4-1,574.9 during the late migration. Whether or not these variations are due to sampling variability or biological/racial factors is presently unknown.

Although direct enumeration is the most accurate method of determining egg content, it is time consuming and restricts numbers of fish which may be examined (Nelson, 1975). In an effort to increase sample size while maintaining a high degree of accuracy, volumetric estimation introduced in 1974 was continued in 1975 (Tables 16 and 17). Evaluation of this method indicated under-counts in both early and late run studies when volumetric estimates were employed. Average percent error was 0.19 and 0.42 in estimating average fecundity of early and late runs, respectively. This is contrary to results obtained in 1974 where over-counts were recorded during both runs.

Results obtained in 1974 indicated volumetric estimates differed from actual egg content by 44.9 and 109.9 eggs in early and late run samples, respectively. In 1975 sampling error was reduced. Differences between actual and estimated fecundity were 14.8 and 13.8 eggs during early and late runs, respectively. It is concluded increased use of volumetric estimates are justified in future investigations and that the relatively small error incurred is negated by permitting larger samples which more accurately represent average egg content within early and late run populations. This is similar to the conclusions of Hartman and Conkle (1960) in their fecundity investigations of Brooks Lake (Alaska) red salmon stocks.

Foerster (1968, p. 126) provides an excellent summary of red salmon fecundity investigations. This summation indicates that average fecundity for various areas were: Babine Lake, 3,273.7 (1946-1949); Lakelse Lake, 3,815.7 (1939, 1948, 1949); Pick Creek, 3,990.0 (1948, 1950-1952); Kurile Lake, 3,967.5 (1929-1932); Port John, B.C., 2,656.6 (1949-1958); Karluk Lake, 3,132.5 (1938-1941); and Cultus Lake, 4,094.2 (1932-1939), (1937-1938). Average fecundity reported by Hartman and Conkel (1960) for Karluk Lake indicate average fecundity in 1958 was 2,762 eggs per female. Foerster (1968) also suggests red salmon from the Bolshays River, Siberia appear to be the greatest egg producers as between 1943 and 1950 these fish averaged 4,789.6 eggs per female. Although these investigations indicate annual fluctuation in average egg content due to size and age class variation, they do provide an index of relative fecundity for different geographical areas.

Early run Russian River salmon averaged 4,050.6 eggs per female for a three-year period. Although future investigations are required to definitively establish mean annual fecundity of this run, it does suggest it is exceptionally high, ranking third behind the Bolshaya River and Cultus Lake. Fecundity of late run Russian River fish averaged 3,335.5 from 1973-1975. This is a greater fecundity than that reported for Babine Lake, Port John, or Karluk Lake, but below fecundities reported for Lakelse Lake, Pick Creek, Kurile, and Cultus lakes. It is well below that reported for the Bolshaya River. Although it is difficult to rank various populations when dealing with fecundity, it is suggested that fecundity of late run Russian River salmon is "intermediate" when compared to other red salmon populations.

Early Run Egg Deposition:

Assuming that average fecundity of early run samples is representative of early run stocks, the potential number of eggs available for deposition in Upper Russian Creek may be calculated. The following assumptions must be applied: (1) sex ratio of the population must be ascertained. Sampling in 1975 indicated a male:female ratio of 1:1.6; (2) annual mortality between weir and spawning grounds is constant, and estimated at 5.1% (Nelson, 1973); (3) mortality between weir and spawning grounds is nonselective and male and female salmon perish in direct proportion to their numbers in the population; (4) numbers of females which reach the spawning grounds and perish without spawning is assumed to be constant and approximately 1.1% as determined by Nelson (1973); and (5) average eggs retained per female was 2.0% of the total eggs available for deposition (Nelson, 1975).

Applying above parameters, estimated potential early run egg deposition may be calculated as follows:

Early run escapement	5,640
Early run female escapement	3,510
Mortality between weir and spawning grounds	5.1%
Female red salmon to reach spawning grounds	3,331
Female red salmon which perished without spawning	37
Remaining female red salmon	3,294
Average eggs per female	3,952
Total possible eggs deposited	13,017,888
Percent eggs deposited per female	98.0%
Estimated potential egg deposition	12,757,530

It should be noted that although escapement in 1975 was 57.1% (7,510) lower than 1974 escapement, potential egg deposition decreased only 28.2% from 1974 estimates. Considerable variability in reproductive potential may exist independent of actual number of spawners (Hartman and Conkle, 1960).

Annual differences in sex ratios can cause substantial differences in eggs available for deposition. Males dominated the 1974 escapement when the sex ratio was 1:0.7. In 1975 this was reversed as 1.6 females escaped for every male in the population. Experiments conducted by Mathisen (1955) indicated mortality of eggs was only slightly higher with a sex ratio as high as 15 female per male than with a male:female ratio of 1:1. Thus, even a highly unbalanced spawning stock favoring females may result in only minor decreases in ultimate egg survival from each female. Such a stock might yield a considerable increase in potential production over stocks of the same size, but with more evenly balanced sex ratios (Hartman and Conkle, 1960).

Average fecundity is also an important factor in determining potential egg deposition. In 1974 early run mean fecundity was 3,569 eggs/female. In 1975 the average fecundity increased by 9.7% to 3,952 eggs/female. Increased fecundity coupled with an unbalanced sex ratio where females predominated therefore accounts for the relatively high potential egg deposition from a relatively small spawning population.

Egg sampling to determine survival and actual egg deposition of early run salmon in Upper Russian Creek was conducted October 16 and 18. Sampling procedures and equipment employed were identical to those described by Nelson (1973). Ninety-eight sampling points were dug. Number of points dug in each section was proportionate to percentage of the run spawning in each section. Egg deposition was estimated at 33.3 eggs/M^2. This is the lowest density recorded since egg sampling was initiated in 1972. Egg survival was 84.3% at time of sampling. Density estimates for 1972-1975 are presented in Table 19.

Table 19. Early Run Russian River Red Salmon Egg Densities Determined by Hydraulic Sampler in Upper Russian Creek, 1972-1975.

Year	No. Points Dug	Total Eggs Dug	Average Eggs Per Point	Survival %	Density (Eggs/M^2)
1972	50	3,790	75.8	81.1	407.8
1973	50	2,967	59.3	93.0	319.6
1974	98	8,229	84.7	64.2	455.6
1975	98	605	6.2	84.3	33.3

Egg density and survival compared to estimated percentage of the run to spawn in each section is presented in Table 20. This Table indicates that early run spawning activities were concentrated in Sections III through VI. This is contrary to 1974 spawner distribution when fish were concentrated in sections VI through IX. It may be that 1975 count was made too early (August 5) and that salmon were still moving upstream. If this is true, sampling was not proportionate to spawner density. However, as logistical considerations permitted only one escapement count, the accuracy of 1975 distribution can not be ascertained.

Egg deposition estimates obtained by hydraulic sampler may also be used to estimate total egg deposition in Upper Russian Creek. Investigations in 1972 divided the stream into ten 200-yard sections. Total spawning area in each section was estimated at 90% of total area available. Multiplying average egg density/M^2 by estimated M^2 of spawning area in each section and summing these results yields an estimated egg deposition of 396,571 in 1975. Similar estimates for 1972, 1973, and 1974 revealed estimated egg deposition to be 5,639,875, 4,420,070, and 6,300,950 eggs, respectively.

Table 21 compares early run egg deposition estimates derived by hydraulic sampler (hereafter referred to as direct method) and fecundity/mortality (hereafter referred to as indirect method) findings. Comparative sections were examined in 1972-1974 and totals presented for these years do not represent estimates for the entire stream. Investigations in 1975 sampled all sections, and the total presented represents total spawning area in Upper Russian Creek.

Table 20. Upper Russian Creek Egg Densities, Egg Survival and Percentage of Total Eggs Dug in Each Section Compared to Numbers of Early Run Red Salmon Enumerated in Each Section, 1975.

Section	No. Points Dug	Total Eggs*	Average Egg Density (M^2)	Average Egg Survival (%)	Percent Total Eggs	Salmon Observed	Percent of Total Salmon
0	7	0				225	6.7
I	1	0				33	1.0
II	5	0				178	5.3
III	15	7	2.5	100.0	;.1	505	15.1
IV	17	253	79.6	81.4	41.8	595	17.8
V	15	10	3.6	100.0	1.7	517	15.5
VI	16	32	10.8	100.0	5.3	526	;5.7
VII	6	8	7.2	87.5	1.3	206	6.2
VIII	6	41	36.8	75.6	6.8	208	6.2
IX	5	9	9.7	77.8	1.5	191	5.7
X	5	245	263.6	85.7	40.5	160	4.8
Total/ Average	98	605	33.3	88.3	100.0	3,344	100.0

* Total eggs refers only to those eyed eggs which were deposited by early run fish and excludes green eggs considered to be of late run origin.

Table 21. Upper Russian Creek Early Run Red Salmon Egg Deposition as Calculated by Direct (Hydraulic Sampler) and Indirect (Fecundity x Number of Females) Methods, 1972-1975.

Section	1972 Deposition		1973 Deposition		1974 Deposition		1975 Deposition	
	Direct (Sampler)	Indirect (Fecundity)	Direct (Sampler)	Indirect (Fecundity)	Direct (Sampler)	Indirect (Fecundity)	Direct (Sampler)	Indirect (Fecundity)
0							0	854,755
I							0	127,575
II							0	676,149
III					0	450,450	3,315	1,926,387
IV	636,210	1,922,400	651,750	2,448,900	125,810	1,559,250	109,538	2,270,840
V	75,465	2,971,710	122,675	3,401,250	524,920	1,663,200	6,143	1,977,417
VI	855,915	4,457,565	800,445	6,326,325	1,253,880	3,898,125	23,211	2,002,932
VII	704,780	2,735,415	697,705	3,968,125	509,070	3,083,850	47,942	790,967
VIII	760,490	2,415,015	193,440	4,126,850	957,775	2,373,525	45,307	790,967
IX					832,255	2,650,725	15,213	727,179
X					174,380	796,950	145,902	612,362
Total	3,032,860	14,502,105	2,466,015	20,271,450	4,378,090	16,476,075	396,571	12,757,530

Calculations involving deposition estimates by direct means are basic, i.e., average eggs/M^2 times number of M^2 in each section. Sum of eggs estimated to be in each section equals estimated number of eggs in the stream. Calculations by indirect means are more complex and are dependent on various assumptions. The reader is referred to Nelson (1975, p. 29) for a summary of these parameters.

Table 21 indicates that major discrepancies exist between direct and indirect methods of estimating egg deposition. Indirect estimation yielded consistently higher results than did direct sampling.

To compare the two methods, theoretical adult return from 1972-1975 spawning populations was calculated with the aid of Foerster's (1968, p. 67) hypothetical mortality table. Computational steps used to determine return for 1975 based on indirect methods are:

1. Determine sex ratio, of (i.e. 1:1.6 or 2,130 males and 3,510 females = 5,640 early run red salmon passed Russian River weir)

2. Determine egg deposition, Upper Russian Creek based on indirect method = 12,757,530

3. Determine egg loss during spawning and incubation - 50% or 6,378,765 alevins remaining

4. Determine alevin loss after emergence and migration to lake - 75% or 4,784,074 fry; remainder 1,594,691 rearing fry

5. Determine loss during lake residence - 92% of 1,467,116 fry; remainder 127,575 smolt

6. Determine ocean mortality - 90% or 114,818 rearing fish; remainder 12,757 adults

7. Return per spawning fish - 2.3

It should be emphasized that Foerster's mortality table is hypothetical and may not approximate mortalities of early run Russian River red salmon at various life history stages. In fact, Foerster has indicated this Table may not truly reflect mortalities in any natural red salmon population. It is designed as a model and mortalities at various stages have been derived from different investigations in numerous geographic areas. Mortalities associated with life history stages of early run Russian River salmon may or may not approximate this theoretical mortality.

It therefore does not necessarily follow that because discrepancies exist between direct and indirect sampling techniques that one or the other method is incorrect. Indirect estimation yields the potential number of eggs which are available for deposition and does not necessarily reflect numbers of eggs in the stream (Nelson, 1975). Direct estimation (providing sampling design is correct) should indicate the number of eggs in Upper Russian Creek at time of sampling. If this is true, survival of eggs and fry must be greater at various developmental stages than Foerster's model suggests. This point will remain unresolved until such time as the magnitude of the early run fry and smolt migration can be determined.

Bear Creek Investigations:

Bear Creek is a relatively small (approximately 5,400 M^2) spring fed tributary on the east side of Upper Russian Lake (see Figures 2 and 7) utilized exclusively by a segment of the late run. Efforts to enumerate late run red salmon in this system by ground counts and tagging programs in 1972 and 1973 were unsuccessful. Intense brown bear, *Ursus arctos*, predation hampered tag recovery. Suspected spawning waves and spawning duration (approximately 1.5 months) negated data obtained from ground counts and tagging programs. Stream life (number of days salmon spent in stream calculated from day fish entered system until death) was also unknown.

In 1974 a temporary weir was constructed on the system. Nelson (1975) reported 5,386 late run red salmon or 21.8% of the 1974 late run escapement spawned here. Salmon were tagged at the weir to determine stream life. Only six tags were recovered from a possible 89. These limited tag recoveries were inconclusive but suggested a stream life in excess of 20 days.

In 1975 the Bear Creek weir was erected on September 8. This was somewhat later than 1974 (August 30) and ground counts indicated 523 salmon had entered the system prior to construction. Ground counts, coupled with salmon passed at the weir, indicated that an estimated 1,138 late run red salmon utilized the system in 1975 (Table 22). This is 3.5% of the total late run escapement and the lowest number (percent) recorded in this area since 1972. Greatest number of salmon to use the stream was in 1972 when it was estimated that 20,461 red salmon (25.9% of the late run escapement) spawned here.

Investigations to date refute the suggestion by Nelson (1973) that the majority of late run Russian River red salmon spawn in this area. Although estimated number of fish was quite high in 1972, only 25.9% of the escapement spawned in Bear Creek. Greatest percentage of the escapement to spawn here was 30.3% in 1973. The possibility does, however, exist that escapements in this system are cyclic and a complete five year cycle must be examined before definitive conclusions can be drawn regarding the importance of Bear Creek as a spawning stream.

Table 22. Daily Late Run Red Salmon Weir Count and Number of Fish Tagged at Bear Creek (Upper Russian Lake) September 15 through October 1, 1975.*

Date	Adults Passed	Jacks Passed	Number Tagged	Cumulative Tagged	Total Passed	Cumulative Total
9/15	0	0	0	0	0	0
9/16	0	0	0	0	0	0
9/17	0	0	0	0	0	0
9/18	7	5	12	12	12	12
9/19	1	0	1	13	1	12
9/20	58	3	60	73	61	74
9/21	6	2	8	81	8	82
9/22	38	1	39	120	39	121
9/23	37	1	38	158	38	159
9/24	1	3	4	162	4	163
9/25	21	0	21	183	21	184
9/26	20	3	14	197	23	207
9/27	3	1	4	201	4	211
9/28	12	1	4	205	13	224
9/29	0	0	0	205	0	224
9/30	91	6	97	302	97	321
10/ 1	24	1	25	327	25	346
Total	319	27	327	327	346	346
						523**
						269***
					Total	1,138

* Weir constructed September 8 and tended from September 15 through October 24. No salmon entered the system after October 5.

** Salmon which entered the stream prior to weir construction.

*** Estimated number of salmon which entered the system between October 1 and October 5. Weir ceased to be a total barrier during this period because of its partial destruction by a brown bear.

Effort in 1975 was again directed toward determining stream life of Bear Creek salmon. During a 14-day period 327 salmon were tagged with serially numbered red Floy tags (Table 22). This type of tag and color were employed in an attempt to minimize predation directed toward study fish. In prior investigations it was believed large brightly colored Petersen disc tags attracted predators. Observations indicate red Floy tags were unobtrusive, blending with the natural spawning coloration of the fish.

Tag recovery was effected by ground survey above weir. Thirty-two surveys were conducted and 12 tagged carcasses recovered (3.7% of total tagged). Only six recoveries could be employed in stream life calculations as remaining carcasses recovered were from bear killed salmon and it could not be ascertained whether these fish perished prior to or after spawning. Stream life based on limited tag recoveries ranged from 14-22 days, averaging 16.4 (Table 23).

Table 23. Stream Life of Late Run Russian River Red Salmon in Bear Creek, Upper Russian Lake, Determined by Tag Recovery, 1975.

Date Tagged	Date Recovered	Area Where Recovered	Sex	Stream Life (Days)
9/21	9/28	Area VIII	Male (J)*	8
9/22	10/13	Area I	Female	22
9/22	10/13	Area VI	Female	22
9/20	10/13	Area VI	Male (B.K.)**	24
9/23	10/10	Area VI	Female (B.K.)**	18
9/23	10/20	Area VI	Female (B.K.)**	28
9/23	10/ 6	Area VIII	Female	14
9/26	10/13	Area VI	Female	18
9/30	10/14	Area VI	Female	15
9/30	10/15	Area VI	Female	16
9/30	10/14	Area V	Female (B.K.)**	15
10/ 1	10/11	Area VIII	Male (B.K.)**(J)*	11
Average				16.4
SD				±4.9

* (J) Jack.

** Bear killed salmon. These tag recoveries were not employed in computing the average stream life as it was not known whether these salmon perished prior to or after spawning.

Limited recoveries again do not justify definitive conclusions regarding stream life. However, coupling these data with results obtained in 1974 suggests mean stream life is of appreciable duration and probably ranges from 15.0-24.2 days. Data from 1973 suggested average stream life was only 10.7 days. This estimate is thought to be too low as day one was the first day the salmon was observed in the stream. Failure to observe the salmon on the first day it entered the system would therefore result in a stream life estimate somewhat less than actually occurred. Furthermore, it is not known if average stream life in Bear Creek is density dependent, i.e., stream life varying as numbers of fish in the system display annual variation. If spawner density is a factor, then it may be expected that stream life will display annual variation.

To facilitate daily ground surveys and determine areas of spawner concentration, Bear Creek was divided into eight areas (Figure 7). These areas were defined as:

Area I	Slough area. Primarily a milling area with very limited spawning
Area II	Approximately 350 linear feet of stream between slough and Beaver Pond
Area II-IV	Includes Beaver Pond and stream between Beaver Pond and Alder Pond I. Areas were combined as spawning was minimal in both areas during 1975.
Area V	Alder Pond I, including stream connecting Alder Pond I with Alder Pond
Area VI	Alder Pond II. This is the largest single spawning area in the system and received largest number of spawning fish.
Area VII	Approximately 340 linear feet of stream below Duck Ponds. Area was not utilized by the 1975 escapement.
Area VIII	Duck Ponds. Area is composed of two ponds connected by approximately 20 feet of shallow stream. Both ponds are utilized for spawning.

Counts revealed Area VI (Alder Pond) was the spawning area for an estimated 43.3% of the 1975 Bear Creek escapement. Area VIII (Duck Ponds) was utilized by an estimated 28.0% of the salmon, while Area V (Alder Pond I) was the spawning grounds for an estimated 20.5% of the escapement. These three ponds therefore accounted for 91.8% of the area utilized by late run Bear Creek red salmon in 1975. Beaver Pond was lightly used as were the areas between ponds. Stream area below Beaver Pond (Area I) received 6.1% of the Bear Creek escapement (Table 24).

Perusal of Table 24 reveals apparent discrepancies between daily counts in respective areas and respective daily totals. Reasons for these inconsistancies are related to: (1) Variations in technique employed by individuals conducting ground surveys. Three individuals made the counts throughout the investigation; (2) Relative numbers of salmon in Bear Creek. Large numbers of salmon are more difficult to enumerate than small numbers; (3) Time of day count was conducted. Angle of the sun affects observers ability to see the fish; (4) Relative cloud cover. Observation is enhanced on bright days, hindered on cloudy days; (5) Numbers of salmon which were removed from the stream area by predators the previous night. Salmon carcasses which were removed from the immediate stream area were difficult to detect and an unknown percentage were undoubtedly not located;

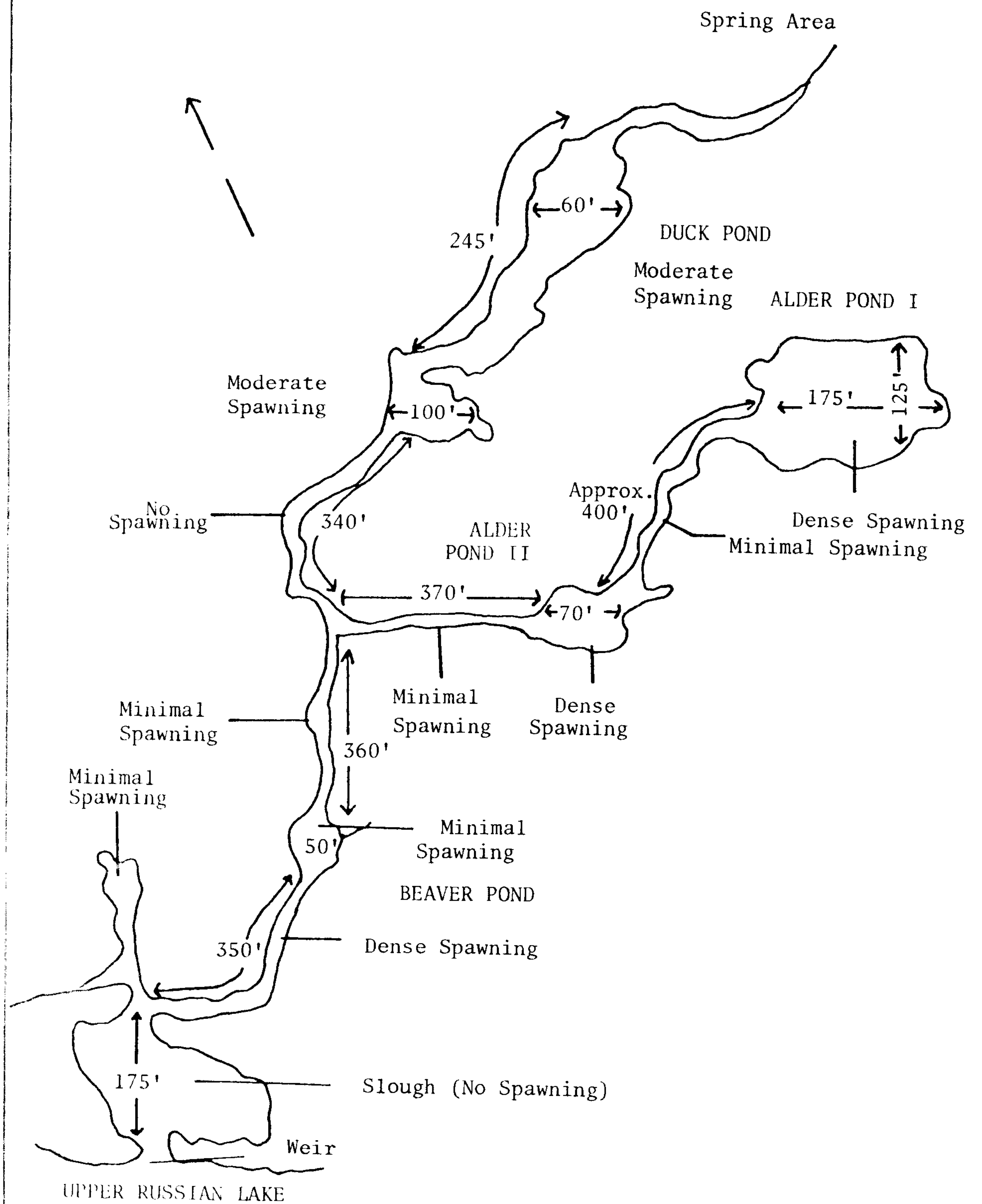

Figure 7. Schematic Diagram of Bear Creek, Upper Russian Lake (Not To Scale).

Table 24

Daily Late Run Russian River Red Salmon Escapement Surveys by Area (Excluding Area I or Slough Area) Conducted at Bear Creek, Upper Russian Lake, September 15-October 21, 1975.

	AREA*													
	Area II		Area III-IV**		Area V		Area VI		Area VII		Area VIII		Total	
Date	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
9/15***	22	5.3	9	2.2	81	19.7	190	46.1	1	0.2	109	26.5	412	100.0
9/16	24	10.3	0	0.0	50	21.4	92	39.3	0	0.0	68	29.0	234	100.0
9/17	15	6.1	3	1.2	73	29.5	82	33.2	0	0.0	74	30.0	247	100.0
9/18	11	5.4	1	0.5	53	26.1	64	31.5	0	0.0	74	36.5	203	100.0
9/19	5	2.9	0	0.0	56	32.8	50	29.2	0	0.0	60	35.1	171	100.0
9/20	4	2.9	0	0.0	40	28.8	41	29.5	0	0.0	54	38.8	139	100.0
9/21	13	4.5	8	2.7	116	39.6	83	28.3	0	0.0	73	24.9	293	100.0
9/22	9	4.2	0	0.0	72	34.1	59	28.0	0	0.0	71	33.7	211	100.0
9/23	25	10.6	2	0.8	60	25.3	77	32.5	0	0.0	73	30.8	237	100.0
9/24	26	12.1	2	0.9	54	25.1	67	31.2	0	0.0	66	30.7	215	100.0
9/25	32	14.7	1	0.5	55	25.3	64	29.5	0	0.0	65	30.0	217	100.0
9/26	34	17.5	1	0.5	37	19.0	60	31.0	0	0.0	62	32.0	194	100.0
9/27	24	11.4	1	0.5	50	23.8	73	34.8	0	0.0	62	29.5	210	100.0
9/28	33	17.1	0	0.0	37	19.2	63	32.6	0	0.0	60	31.1	193	100.0
9/29	22	13.8	0	0.0	28	17.6	60	37.8	0	0.0	49	30.8	159	100.0
9/30	47	18.0	60	23.0	37	14.2	64	24.5	0	0.0	53	20.3	261	100.0
10/1	26	6.5	36	9.0	71	17.8	187	46.9	2	0.5	77	19.3	399	100.0
10/2						No Survey								
10/3						No Survey								
10/4						No Survey								
10/5						No Survey								
10/6	26	4.0	54	8.3	132	20.3	328	50.4	4	0.6	107	16.4	651	100.0
10/7	22	5.1	0	0.0	97	22.3	218	50.2	0	0.0	97	22.4	434	100.0
10/8	9	1.6	1	0.2	82	14.6	346	61.7	0	0.0	123	21.9	561	100.0
10/9	8	2.1	0	0.0	67	17.8	201	53.5	0	0.0	100	26.6	376	100.0
10/10	6	1.3	2	0.4	53	11.3	297	63.2	0	0.0	112	23.8	470	100.0
10/11	6	1.4	0	0.0	47	11.1	259	61.4	0	0.0	110	26.1	422	100.0
10/12	18	4.4	0	0.0	53	12.9	234	56.9	0	0.0	106	25.8	411	100.0
10/13	12	3.3	0	0.0	52	14.3	199	54.7	0	0.0	101	27.7	364	100.0
10/14	0	0.0	7	2.2	45	13.9	181	55.8	0	0.0	91	28.1	324	100.0
10/15	1	0.3	10	2.9	58	16.9	182	52.9	1	0.3	92	26.7	344	100.0
10/16						No Survey								
10/17	1	0.4	7	2.8	37	14.9	135	54.2	0	0.0	69	27.7	249	100.0
10/18	7	2.7	3	1.2	42	16.3	140	54.2	0	0.0	66	25.6	258	100.0
10/19	4	1.6	6	2.5	40	16.5	119	49.0	0	0.0	74	30.4	243	100.0
10/20	6	2.5	4	1.7	42	17.6	120	50.2	1	0.4	66	27.6	239	100.0
10/21	6	2.9	0	0.0	34	16.2	108	51.4	0	0.0	62	29.5	210	100.0
Average	15.7	6.1	6.8	2.0	57.8	20.5	138.8	43.3	0.3	0.1	78.9	28.0	298.5	100.0
SD	11.7	5.4	14.8	4.4	23.5	6.9	86.5	12.1	0.8	0.2	20.4	4.8	121.4	

* Area I deleted as it is primarily a milling rather than spawning area.

** Areas III and IV combined as spawning was minimal in both areas.

*** Escapement survey of 9/15 was a total count only. Apportionment by area assumed to be the average distribution determined by 31 succeeding escapement surveys.

(6) Undetected immigration of salmon through the weir. Between October 1 and October 5 the weir was partially destroyed by brown bear and an undetermined number of salmon entered the stream; (7) Daily movement of salmon from one area of the stream to another may partially account for daily count variation between areas, but would not affect estimated total number of salmon in the system; and (8) A combination of any or all of the above may account for the apparent disparity between daily counts in respective areas and total estimated salmon in Bear Creek.

To determine the validity of estimated numbers of red salmon in the various areas of Bear Creek, the theoretical daily number of salmon in the system was calculated (Table 25). This table considers the relationship between salmon passed at weir, previous days escapement count, salmon carcasses observed, and daily live salmon counts.

Table 25 indicates that appreciable differences between actual and theoretical numbers of salmon in Bear Creek occurred when individual days are considered. Counts over and under the theoretical estimate were equally divided. Percent error ranged from a low of ±1.5 (four days) to a high of ±65.9% on September 30. The salient point is, however, that the average percent error, as calculated from 30 escapement surveys, was only ±2.8%. Numbers of salmon spawning in a given day in a particular area may have been grossly over or under estimated. However, Table 25 suggests that the observed number of salmon in Bear Creek closely corresponds with the theoretical number of salmon which were expected to be in the system.

Bear Creek investigations were again further complicated by intense brown bear predation. Eleven individual bears were identified. In an effort to evaluate effects of predation on late run stocks, bear-killed salmon carcasses were enumerated during daily escapement surveys (Table 26).

Table 26 indicates the intensity of brown bear predation in this small system. It is estimated 973 salmon perished as a direct result of bear activity. This is 85.5% of the estimated salmon to enter the creek. This figure is assumed to be minimal as: (1) All carcasses were undoubtedly not located, and (2) Spawning and concommitant predation was still occurring when project was terminated on October 24. Observation indicated that the entire salmon was utilized as in most cases only the jaws and fins remained. It was therefore not possible to determine whether or not salmon were spent at time of death.

Investigations conducted by Gard (1971) on red salmon of Grassy Point Creek, a tributary of Karluk Lake on Kodiak Island, Alaska, indicated bears were efficient predators, killing up to 79% of the salmon in the creek in 1964. He further indicated that only 9.6% of the dead females sampled were unspawned bear-killed fish. Males appeared to act as a buffer against predation on females. Gard concluded bear predation has little adverse effect on red salmon production.

Table 25

Relationship Between Numbers of Late Run Russian River Red Salmon Which Entered Bear Creek, Carcasses Recovered, and Daily Escapement Surveys, Upper Russian Lake, 1975.

Date	Salmon Passed at Weir (Previous Day(s)	Count (Previous Day)	Theoretical No. Salmon in Bear Creek	Today's Count	Today's Carcass Count*	Salmon Over or Under Theoretical Count**	Percent Error**
9/15				412			
9/16	0	412	412	408	35	+ 31	+ 7.5
9/17	0	408	408	386	33	- 11	- 2.7
9/18	0	386	386	342	19	+ 25	+ 6.5
9/19	7	342	349	270	33	+ 46	+13.2
9/20	1	270	271	305	30	- 64	-23.6
9/21	58	305	363	402	24	- 63	-17.3
9/22	6	402	408	334	28	+ 46	+11.3
9/23	38	334	372	352	40	- 20	- 5.4
9/24	37	352	389	328	39	+ 22	+ 5.7
9/25	1	328	329	301	8	+ 20	+ 6.1
9/26	21	301	322	298	29	- 5	- 1.5
9/27	20	298	318	337	31	- 50	-15.7
9/28	3	337	339	301	33	+ 5	+ 1.5
9/29	12	301	313	217	21	+ 75	+24.0
9/30	0	217	217	335	25	-143	-65.9
10/1	91	335	426	460	3	- 37	- 8.7
10/2-10/5			No Escapement Survey				
10/ 6***	24+	460	484+	700	32	Unknown	Unknown
10/ 7	0	700	700	519	35	+146	+20.9
10/ 8	0	519	519	626	27	-134	-25.8
10/ 9	0	626	626	451	23	+152	+24.3
10/10	0	451	451	545	77	-171	-37.9
10/11	0	545	545	494	86	- 35	- 6.4
10/12	0	494	494	481	65	- 52	-10.5
10/13	0	481	481	413	59	+ 9	+ 1.9
10/14	0	413	413	335+	35	+ 43	+10.4
10/15	0	335	335	372	42	- 79	-23.6
10/16			No Escapement Survey				
10/17	0	372	372	261	77	+ 34	+ 9.1
10/18	0	261	261	270	28	- 37	+14.2
10/19	0	270	270	257	7	+ 6	+ 2.2
10/20	0	257	257	258	3	- 4	- 1.5
10/21	0	258	258	253	21	+ 4	+ 1.5
Total	319	11,770	12,088	12,003	1,048	-241	-86.2
Average		377.0	386.8	364.6	33.8	- 8.0	- 2.8
SD		± 113.5	± 110.8	± 98.7	± 20.7	± 71.8	±19.1

* Carcass count includes natural mortality and mortality attributed to predation.
** Positive number (%) indicates count less than the theoretical escapement; negative number (%) indicates a count greater than the theoretical escapement.
*** October 6 was deleted from calculations as an unknown number of salmon entered the Creek between October 2 and 5.

Table 26

Relationship Between Total Live Count, Whole Carcasses Recovered and Late Run Russian River Red Salmon Subject to Predation, Bear Creek, Upper Russian Lake, 1975.

Date	Total Live Count	Total Whole Carcasses Recovered	Carcass Remains From Predation	Total Salmon Enumerated
9/15	523	0	0	523
9/16	408	0	35	443
9/17	386	0	33	419
9/18	342	0	19	361
9/19	270	0	33	303
9/20	305	1	29	335
9/21	402	2	22	426
9/22	334	1	27	362
9/23	352	1	39	392
9/24	328	8	31	367
9/25	301	2	6	309
9/26	298	0	29	327
9/27	337	0	31	368
9/28	301	4	29	334
9/29	217	1	20	238
9/30	335	0	25	360
10/ 1	460	1	2	463
10/ 2-10/ 5		No Escapement Surveys		
10/ 6	700	2	30	732
10/ 7	519	2	33	554
10/ 8	626	4	23	653
10/ 9	451	2	21	474
10/10	545	7	70	622
10/11	494	5	81	580
10/12	481	6	59	546
10/13	413	3	56	472
10/14	335+	9	26	369
10/15	372	7	36	414
10/16		No Survey		
10/17	261	3	74	338
10/18	270	3	25	298
10/19	257	1	6	264
10/20	258	0	3	261
10/21	253	1	20	254
Total	12,114	76	973	13,161
Average*	378.5	2.4	30.4	411.3
SD	± 116.6	±2.6	±19.7	±122.9

* Average computed on basis of 32 escapement surveys.

Schuman (1950) also investigated brown bear predation in the Karluk River system. Observation by that author in 1945 revealed between 25-33% of all salmon reaching the spawning grounds were destroyed by bear. On several streams it was found that bear were destroying every salmon that entered the system. In 1947 a weir was constructed on Moraine Creek, a tributary of Karluk Lake. Escapement to this stream was 14,826 red salmon. Schuman concluded that the minimum number of unspawned salmon attributed to bear depredation was 4,640, or 31.3% of the escapement. He further estimated the loss of Karluk red salmon to brown bear predation was a minimum of 94,119 salmon in 1947. Schuman concluded that this loss was most significant in view of the depressed nature of the Karluk stocks and recommended immediate control of the bear population.

The salient point in discussing red salmon losses attributed to brown bear predation appears to center on whether or not the fish were spent before they were killed. If the fish were spent, impact of bear predation on reproductive potential would be inconsequential. If the fish were not spent, and the spawning escapement depressed, effects could be significant.

To determine effects of bear predation on Bear Creek stocks and to determine egg deposition in various areas of the stream, egg sampling was again conducted. Areas sampled and methodology employed were identical to 1974. Sampling results from 1972 through 1975 are presented in Table 27.

Table 27. Bear Creek (Upper Russian Lake) Late Run Red Salmon Egg Densities by Area, 1972-1975.

	Year			
	1972 Egg Density (M^2)	1973 Egg Density (M^2)	1974 Egg Density (M^2)	1975 Egg Density (M^2)
Alder Pond	3,239	979	1,067	1,473
Duck Pond	2,668	874	361	209
Beaver Pond	1,905	534	263	11
Alder Pond I	____	____	2,900	321
Average Density	2,604	796	1,148	503

Average density for the entire stream was estimated to be 503 eggs/M^2. This is the lowest density recorded since 1972 and is 56.2% lower than 1974 estimates.

Escapement in 1975 was 78.9% lower than 1974 escapement. The sex ratio in 1974 favored females (1:1.1) while in 1975 males dominated the late run escapement (1:0.9). Fecundity in 1975 was also slightly greater (average of 293.2 eggs/female). This information coupled with the estimated percentage of the escapement to spawn in various areas of Bear Creek gives an approximate estimation of the potential egg deposition compared to the actual egg deposition determined by hydraulic sampler (Table 28).

Table 28. Theoretical Egg Deposition in Four Areas of Bear Creek (Upper Russian Lake) as Calculated from the Estimated Number of Female Red Salmon to Spawn in Each Area and Estimated Density Determined by Hydraulic Sampler, 1975.

Area	Female Red Salmon	Average Fecundity	Theoretical Density (M^2)	Actual Density (Hydraulic Sampling) (M^2)
Alder Pond	189	3,568.4	507	1,473
Duck Pond	115	3,568.4	274	209
Alder Pond I	82	3,568.4	366	321
Beaver Pond	1	3,568.4	6	11

Table 28 indicates close agreement between theoretical and actual egg density in three of four areas sampled. Disparity exists in Alder Pond where actual density greatly exceeds theoretical. It is not definitely known why theoretical and actual density in this area are not in closer agreement. However, the disparity might be attributed to: (1) sampling error because points dug by hydraulic sampler contained greater numbers of eggs than other areas of the pond, and (2) error in enumeration of adults utilizing this area. Alder Pond is relatively large and contained the greatest number of spawning fish. It was therefore the most difficult to enumerate.

The important point to consider, however, is that numbers of estimated eggs deposited approximates or exceeds numbers of eggs estimated to be potentially available. It is therefore concluded that although data indicates brown bear predation was intense, depredation had an inconsequential effect on reproductive potential of the 1975 escapement in this stream. It is also concluded that the majority of the salmon killed by bears were spent.

Additionally, Table 28 suggests a high degree of accuracy (except in Alder Pond) may be attributed to daily escapement surveys.

Table 29 presents the area available per spawning salmon in four Bear Creek ponds. This Table indicates that area available per spawning female was adequate and that crowding was not a factor in 1975. Foerster (1968) has summarized the work of other investigators regarding capacity of the spawning grounds. Burner (1951), working with Columbia River red salmon, concluded a pair of spawning salmon would require approximately 6.69 M^2. This criteria was met in all areas of Bear Creek. Mathisen (1955) arrived at similar conclusions while conducting experiments at Pick Creek on the Wood River system, Bristol Bay, Alaska. He concluded that each female required approximately 3.7 M^2 of spawning territory. Krokhin and Krogius (1937) calculated that a spawning female occupied 1.0 M^2 when spawning in a spring area (Bear Creek is spring fed).

It is therefore assumed that crowding did not occur in any area of Bear Creek in 1975. Observation indicated salmon were not forced into marginal or poor spawning areas and in several areas (Duck and Beaver Ponds) a larger spawning escapement could have been accommodated. Available information therefore suggests that should optimum environmental factors occur during the winter 1975-1976, survival to the fry stage should be relatively high.

Table 29. Estimated Egg Density and Estimated Area Available Per Spawning Late Run Russian River Female Red Salmon in Bear Creek, Upper Russian Lake, 1975.

Area	Total Salmon	Salmon/M^2 of Gravel	Female Salmon	Estimated Area Available/Female (M^2)	Egg Density (M^2)
Alder Pond I	398	3.3	189	7.0	1,473
Duck Pond	243	6.2	115	13.0	209
Alder Pond II	174	4.6	82	9.7	321
Beaver Pond	3	206.7	1	62.0	11
Total/ Average*	815	4.7	386	9.9	668

* Beaver Pond deleted from computations.

Critical observation during egg sampling revealed egg survival estimates obtained by hydraulic sampler were invalid. Eggs sampled were "green", i.e., had not eyed. Death as a result of shock from the air and water mixture was virtually instantaneous. Survival estimates were therefore not obtained. It is also concluded that survival estimates for this system as reported for the years 1973-1974 are too low and do not accurately reflect true survival rates. High egg densities and high survival rates (94.8%) were reported in 1972. Reasons for these high survival rates are unknown as sampling for all years was done at approximately the same time (October) and eggs in all years had not yet eyed.

Female carcasses were opened in conjunction with Bear Creek spawning ground surveys. Fifty percent of the females were totally spent, i.e., no eggs retained. One to fifty eggs were retained by 42.7% of the sample. Only 2.9% of the females examined were unspawned. Average (weighted) egg retention was estimated to be 108.7 eggs per female (Table 30).

Table 30. Egg Retention of Untagged Late Run Russian River Red Salmon in Bear Creek, Upper Russian Lake, 1975.

Eggs Retained (Range)	Average Eggs Retained	Number of Red Salmon	Percent of Total Sample
0	0.0	34	50.0
1-50	4.2	29	42.7
51-100	52.0	1	1.5
100-450	404.0	2	2.9
Unspawned	3,568.4*	2	2.9
Total/Average	108.7*	68	100.0

* Eggs retained calculated as average fecundity of late run females.

** Weighted average.

These results are similar to 1974 egg retention estimates. In 1974, 2.0% of the females sampled in Bear Creek were unspawned. The percentage of the sample completely spent was, however, somewhat lower, i.e., 41.1% compared to 50.0% in 1975. Average egg retention in 1974 was lower (80.5 egg/female) compared to 108.7 eggs per female in 1975. Investigation in 1973 indicated 2.4% of the females in this system perished without spawning. Percentage of unspawned females in Bear Creek has therefore remained relatively constant at less than 3.0% annually. Percentage of females to expell all eggs in 1973 was only 18.4% compared to 41.1% and 50.0% in 1974 and 1975, respectively. Probable explanation for high egg retention in 1973 is advanced by Foerster (1968) in that "....when runs are heavy and where competition for spawning ground is very keen, the number of undeposited eggs in female fish and number of females dying unspawned increases." Escapement in 1973 exceeded that of either 1974 or 1975.

Forty-nine female salmon were recovered from the shoal area of Upper Russian Lake. Greatest percent of the salmon examined (65.3%) retained one to fifty eggs (Table 31). Average (weighted) retention was 43.5 eggs/female. This is somewhat less than reported for Upper Russian Lake proper in 1974. Average egg retention for that year was 119.1 eggs per female.

Table 31. Egg Retention of Late Run Russian River Red Salmon Recovered from the Shoal Area of Upper Russian Lake, 1975.

Eggs Retained (Range)	Average Eggs Retained	Number of Red Salmon	Percent of Total Sample
0	0	10	20.4
1-50	11.3	32	65.3
51-100	84.7	3	6.1
101-300	222.0	3	6.1
301+	850.0	1	2.1
Total/Average	43.5*	49	100.0

* Weighted Average

Ground counts of other late run spawning areas tributary to Upper Russian Lake were made in conjunction with Bear Creek investigations. Counts were conducted at Upper Russian Creek, between Upper and Lower Russian Lake, and on three small tributaries of minor importance (Table 32).

Table 32. Surveys of Late Run Russian River Red Salmon Spawning Areas, Upper Russian Lake, 1975.

Area	Type of Count	Red Salmon
Bear Creek	Weir	1,138
Upper Russian Creek	Ground Survey	1,369
Upper Russian River	Ground Survey	800
Canyon Creek	Ground Survey	200
Beaver Creek	Ground Survey	25
Bog Creek	Ground Survey	0
Upper Russian Lake	Extrapolation	28,438

Escapement estimates in Canyon and Beaver Creek were somewhat subjective as all salmon did not simultaneously enter these streams. Escapement figures are therefore estimates derived from observation of salmon schooling off the mouth. No salmon were observed spawning in Bog Creek nor were fish observed off the mouth.

Salmon spawning in Upper Russian Lake cannot be visually enumerated. A survey of the lake shore on October 7 revealed 381 adult red and six silver salmon. Three overnight gill nets in various locations of the lake resulted in capture of only one partially spent female red salmon. Spawner distribution in Upper Russian Lake proper is therefore unknown. For this reason the estimate of spawning fish in this area was assumed to be the total red salmon escapement minus the sum of escapement counts.

Access Denial Investigations:

It was originally anticipated that a limited number of Bear Creek salmon would be denied access to their natal stream. These fish would be seined in front of the weir and placed in pens adjacent to Bear Creek. Purpose of this experiment was to determine if red salmon could be induced to spawn in the shoal area of the lake rather than their stream of origin. Plans were to capture the salmon in mid-October. Logistical considerations prevented personnel from tending the weir from October 2-5. During this period brown bear(s) partially destroyed the weir, permitting remaining salmon to enter the stream undetected. Access denial investigations were therefore not conducted in 1975.

IHN Investigations:

Infectious hematopoietic necrosis (IHN) is a viral disease which initially attacks blood forming tissue of the kidney. The first recorded outbreak occurred at Oregon's Willamette Hatchery in 1954. Losses have also been reported from hatcheries in California, Washington, and British Columbia (Wood, 1974). In 1975 it was reported in artificially propagated Alaskan red salmon. Losses occurred in Auke Creek Hatchery, Sitka estuarine rearing pens in Southeast Alaska, and in Kitoi Bay Hatchery on Afognak Island, (Grischkowsky, 1975, ADF&G pathology laboratory, Unpublished). In order to better define the distribution of IHN in wild Alaskan red salmon stocks a survey was initiated in 1975.

Sampling at Upper Russian Lake was conducted by Dr. Roger S. Grischkowsky, fishery pathologist for the Fisheries Rehabilitation and Enhancement Division (FRED) of the Alaska Department of Fish and Game, with the assistance of Sport Fish Division personnel. One hundred thirty-five salmon (55 males and 80 females) were taken from the early run at Upper Russian Lake. Bear Creek sample was composed of 75 males and 75 females. Analysis was conducted at Biometrics, Inc., of Tacoma, Washington.

In both early and late run Russian River samples, female pools (five fish/pool) were 100% positive for the disease. Male pools from early and late runs were 45.5% and 20.0% positive, respectively. Sampling at Tustumena Lake (Kenai Peninsula) was negative, as were samples from Lake Nerka (Bristol Bay). The remaining nine red salmon areas sampled in 1975 indicated the presence of the virus in the female sample (range 6.7% to 60.0%). Only two of these nine samples were positive in the male pools. The Upper Russian Lake system was the only area sampled in which all female pools were 100% positive. Although this testing definitely establishes the disease in the Russian River red salmon population, its effects on reproductive potential are not known.

Climatological Observations:

Air and water temperatures recorded at Lower Russian Lake weir were grouped by six-day periods to facilitate analysis (Table 33). No correlation could be determined between air and/or water temperature and red salmon migration. Total rainfall recorded during the 60-day period was 62.8 mm (2.5"). Rainfall recorded in this area has little effect on volume of water in Russian River. Precipitation and runoff at Upper Russian Lake is of much greater significance.

Stream depth exhibited appreciable fluctuation during the red salmon migrational period. Maximum height (volume) occurred during the early run migration between July 7-12. This also corresponded to maximum air temperature which may have precipitated runoff in Upper Russian Lake drainage. Seasonal variation in stream depth was 285.2 mm (11.2").

Table 33. Climatological and Hydrological Observations by Six-Day Period Recorded at Lower Russian Lake Weir, July 1-August 29, 1975.

Period	Air Temperature* Max. C	Min. C	Water Temperature* Max. C	Min. C	Rainfall (mm)**	Stream Depth (mm)*
7/ 1-7/ 6	19.5	6.4	11.5		1.2	541.9
7/ 7-7/12	23.7	8.9	14.3	13.1	17.5	556.7
7/13-7/18	16.7	6.9	13.4	12.3	11.4	512.3
7/19-7/24	15.6	7.1	13.6	12.8	5.7	409.6
7/25-7/30	17.9	6.8	13.6	12.6	5.2	370.4
7/31-8/ 5	17.9	7.7	14.1	12.7	6.2	349.3
8/ 6-8/11	17.0	8.1	15.0	13.4	8.0	329.2
8/12-8/17	16.7	10.5	14.8	13.8	4.1	324.8
8/18-8/23	16.0	6.6	14.3	12.8	2.2	310.1
8/24-8/29	15.8	6.0	14.1	12.6	1.3	271.5

* Air temperature, water temperature and stream depth for the periods are the average of six consecutive daily recordings.

** Rainfall for each period is the cumulative total of six daily recordings.

Although quantitative data was not obtained, observation indicated that a temporary velocity barrier delayed early run passage between July 7-12. This delay probably did not exceed two or three days and it is assumed early run reproductive potential was not affected.

Climatological observations at Upper Russian Lake were also grouped by six-day periods. Emphasis was placed on ascertaining precipitation and determining temperature fluctuation in Bear Creek.

No correlation could be determined between water temperature, rainfall, and immigration of late run red salmon to Bear Creek. Climatological observations recorded at Upper Russian Lake are summarized in Table 34. 2/

2/ Daily climatological observations recorded at Upper and Lower Russian Lakes are on file at the Soldotna office of the Alaska Dept. of Fish and Game.

Table 34. Climatological and Hydrological Observations by Six-Day Period Recorded at Upper Russian Lake, September 16-October 20, 1975.

Date	Air Temperature C*	Lake Temperature** Max. C	Lake Temperature** Min. C	Bear Creek Temperature** Max. C	Bear Creek Temperature** Min. C	Rainfall (mm)***
9/16-9/21	10.6	11.6	10.8	7.9	4.9	39.0
9/22-9/27	11.5	11.9	10.7	7.5	4.6	6.6
9/28-10/ 3	9.2	11.5	10.2	5.3	3.1	33.0
10/ 4-10/ 9	5.6			4.1	1.4	4.0
10/10-10/15	6.1			4.4	3.2	115.7
10/16-10/21	3.3	5.2****	2.2****	3.9	2.1	13.4

* Air temperature taken at 1200 hours and assumed to be the daily maximum. Temperature for the six-day period is the average of six daily recordings.

** Water temperatures for the periods are the average of six daily recordings.

*** Rainfall is the cumulative total for that period.

**** Based on a single days' recording on October 21, 1975.

DISCUSSION

Creel census statistics collected during Russian River red salmon sport fishery revealed a harvest of 9,790 sockeye salmon. Early and late runs contributed 1,400 and 8,390 salmon, respectively, to this harvest. Angler effort directed toward early and late run populations was estimated at 5,210 and 11,300 man-days, respectively.

Sport anglers harvested 19.9% of the early run to reach Russian River. This is a reduction of 47.7% compared to the historical mean harvest rate of 38.1% and appreciably less than the 1969-1971 catch rate when over 50% of the adult return was harvested. Factors contributing to this low harvest rate are: (1) reduction in the early run bag and possession limit from three to one salmon, (2) relatively small size of the 1975 early run, (3) extension of the sanctuary area from 500-700 yards, and (4) emergency closure which limited exploitation of early run stocks by sport anglers.

Late run red salmon did not enter the sport fishery until July 25. Escapement levels indicated a smaller than average run in progress so the fishery was closed on August 13, limiting the numbers of late run salmon available to sport anglers.

Red salmon escapements were enumerated by weir at the outlet of Lower Russian Lake. This site allows total stock enumeration after the runs have passed through the Cook Inlet commercial and Russian River sport fisheries. Sport salmon fishing is prohibited above the weir and mortality between weir and spawning grounds is attributable to natural causes.

Early run escapements began to pass the weir on June 25, twelve days later than in 1974, and five days later than the historical arrival date of June 20. Early run passage was complete by July 27 and totaled 5,640, or 50.5% less than the historical average.

Return per spawner for early run red salmon have ranged from 0.3-2.1, averaging 1.1. Return per spawner in 1975 is estimated at 1.4 (based on an estimated 5,000 fish escapement in 1969). Analyses of available data indicate greatest returns are not necessarily produced from large spawning populations. Greatest return per spawner was 2.1 which resulted from a parent year escapement of 9,200 salmon. Coupling data based on return per spawner with the known spawning area of Upper Russian Creek suggests optimum early run escapements of between 9,000 and 13,000 salmon. It is, however, recognized that adequate escapement levels do not necessarily insure an adequate return. Climatological factors, disease, predation, etc., may depress the run even though adequate numbers of spawning salmon were initially present. Annual fluctuations will probably continue to occur despite escapements which are considered adequate or optimum for the system.

Late run Russian River escapements of red salmon have ranged from 21,820 (1965) to 79,000 (1972), averaging 41,063. Escapement in 1975 was 31,970. Ground surveys below Russian River Falls indicated an additional 690 salmon spawning in this area. Total late run escapement to Russian River drainage is therefore estimated at 32,660. Although the escapement which passed the weir is somewhat below the historical average it is considered adequate for this system.

Anglers harvested 20.8% of the late run (exclusive of fish spawning below the falls) to reach Russian River. This is an increase over the historical harvest rate of 12.1%.

No precocial males (jacks) were observed in the early run migration. In excess of 1,700 jacks were observed in the late run escapement. Data are available which suggest that jack escapement of this magnitude may indicate a greater than average return the following year.

It is of interest to note that the majority of the jack return passes the weir seven days later than the majority (50%) of the adult return. It is not known whether this timing differential is racial or dependent on physical factors. Water levels are lower later in the migrational period and may facilitate passage of these small salmon. Larger adults may more readily negotiate the Russian River Falls at greater velocity levels and arrive earlier at the weir.

Comparison of Kenai River sonar counts with Russian River weir data indicate the distance of approximately 58 miles from Kenai River Bridge in Soldotna to Russian River was negotiated by the average late run salmon in 13 days, or an estimated 4.5 miles per day. Whether travel speed is constant or irregular while salmon are in the Kenai River is unknown. It is known, however, that this run requires approximately six days to traverse the three miles from Kenai and Russian River confluence to the weir (Engel, 1971). Data also indicates Russian River late run stocks comprised 25.3% of the red salmon to enter the Kenai River system. Although this is below the historical average contribution of 43.2%, it did establish Russian River as the primary contributor in 1975.

Scale analysis indicated both early and late runs were dominated by salmon which resided two years in Upper Russian Lake. Early run salmon were primarily three-ocean (78.2%) while the majority of the late run spent two years in the marine environment. Escapements in 1969 and 1970 were the primary contributors to 1975 early and late run escapements, respectively. Early run salmon averaged 588.3 mm in length. Adult late run escapement averaged 531.3 mm. Average sizes of two-and three-ocean salmon from early and late runs were in close agreement. This suggests that growth in the marine environment was similar for both runs and that differences in average size of salmon in the two runs is related to age structure of the respective populations rather than differential growth rates between runs.

Available data indicate that ocean ages of both runs could be ascertained by length-frequency. It was concluded, however, that this technique is of questionable value in determining the age of individual salmon due to the great variation in size of salmon in their respective age groups.

Fecundity investigations revealed early and late run salmon averaged 3,952 and 3,555 eggs per female, respectively. Early run salmon averaged 1,556.1 eggs per kilogram of body weight and 6.6 eggs per millimeter of body length. Late run fish averaged 1,574.9 eggs per kilogram of body weight and 6.4 eggs per millimeter of body length. In the majority of the samples examined the left ovary contained a greater number of eggs than did the right ovary.

Foerster (1968) concluded that a direct relationship exists between fish size and egg content, i.e., the larger the salmon the greater the egg content. Fecundity investigations at Russian River initially confirmed this supposition, as larger early run red salmon have consistently carried more eggs than smaller late run fish.

Direct enumeration and volumetric estimates were employed to determine egg content. Evaluation of volumetric estimates indicated average percent error was 0.19 and 0.42 during early and late runs, respectively. Numeric differences between fecundity estimates for early and late runs were 14.8 and 13.8 eggs, respectively. It is concluded that the relatively small error justifies continued use of volumetric estimates in future fecundity investigations.

Average annual fecundity (1973-1975) of early run Russian River red salmon is estimated to be 4,050.6 eggs per female. Comparison of this runs' fecundity with results obtained from other geographic areas indicates it is exceptionally high. Fecundity of late run Russian River salmon averaged 3,335.3 from 1973 through 1975. Although the difficulties in ranking fecundity of various populations are recognized, data suggest average fecundity of these fish is "intermediate" when ranked with other geographic areas.

Potential number of eggs available from early run salmon for deposition in Upper Russian Creek was calculated employing parameters outlined by Nelson (1974). Potential egg deposition was estimated to be 12,757,530. This number is 28.2% lower than that estimated for 1974 even though escapement was 57.1% less than the prior years' escapement. This apparent disparity indicates the importance of sex ratio and fecundity in that: (1) Males dominated the 1974 escapement while females outnumbered males (1:1.6) in 1975, and (2) fecundity of the average female in 1975 exceeded average female egg content in 1974.

Egg sampling to determine egg survival and actual deposition was conducted in Upper Russian Creek following the cessation of early run spawning. Egg deposition was estimated at 33.3 eggs/M^2. This is the lowest density recorded since 1972. Total deposition from direct sampling is estimated at 396,571 eggs. It is therefore evident that appreciable differences exist between the estimated potential deposition and actual number of eggs in Upper Russian Creek. However, it does not necessarily follow that because discrepancies exist between these two methods that one or the other is incorrect.

Indirect estimation yields the potential number of eggs theoretically available for deposition and does not allow for: (1) death of spawners between weir and Upper Russian Creek, (2) females which died from natural causes or predation on the spawning grounds, (3) loss of eggs through super-imposition, (4) number of eggs retained by females, (5) eggs lost to predation, and (6) eggs expelled from the female but not deposited in the gravel. Direct estimation considers these factors and should indicate numbers of eggs in the gravel at time of sampling.

A weir constructed at Bear Creek (Upper Russian Lake) revealed 1,138 late run salmon spawned in this Upper Russian Lake tributary. Tagging data from this and prior years indicated stream life of red salmon in this system ranged from 15.0 to 24.2 days.

Data indicates brown bear predation was intense in 1975. It was further estimated that bears killed 973 salmon, or 85.5% of the Bear Creek escapement. Carcass examination could not ascertain whether or not these salmon were spent at time of death.

To determine egg deposition in Bear Creek and to determine the effects of predation on these stocks, hydraulic egg sampling was conducted. Average density for the entire stream was estimated at 503 eggs/M^2. This is the lowest density recorded since 1972. Potential density was also calculated. Comparison of these density estimates revealed that the actual number of eggs found in three areas of Bear Creek approximated the potential number of eggs which would theoretically be in these areas. In one sampling area the actual number of eggs exceeded the estimated potential. The salient point is that the number of eggs deposited in Bear Creek is as great as the number of estimated eggs potentially available. It is therefore concluded that brown bear predation had minimal or no effect on the reproductive potential of this stream.

Nelson (1973) suggested the majority of late run red salmon spawned in Bear Creek. In 1975 only 3.5% of the late run spawned here. Highest estimated percentage of the run to use the areas was 30.3% in 1973. Since investigations have been initiated in 1972, Upper Russian Lake proper has been the spawning area for the majority of late run salmon. This suggests that Bear Creek investigations be reduced and increased emphasis be placed on evaluating red salmon production in the lake proper.

Sampling in 1975 revealed the presence of infectious hematopoietic necrosis (IHN) in both early and late Russian River runs. One hundred percent of the female samples collected during both runs were positive. Male pools from early and late runs were 45.5 and 20.0% positive, respectively. Although IHN is known to cause high mortalities in hatcheries, its effect on natural reproduction in Upper Russian Lake is unknown.

Climatological data was recorded at Lower and Upper Russian lakes. No correlation was found between water temperature and immigration of salmon through Russian River or into Bear Creek. Stream depth (volume) coupled with observation at Russian River Falls suggested early run salmon were delayed two or three days due to high water conditions. This delay is assumed to have had no effect on early run reproductive potential.

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